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ABRIDGED AGRICULTURAL RECORDS
IN SEVEN VOLUMES

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26907

A Compilation of such Bulletins and Reports
as are Indispensable to the Practical Farmer

VOLUME VII

FARMING METHODS.—SOILS, FERTILIZERS, IRRIGATION, ROTATION, BUILDINGS. FARMER'S HOME AND EDUCATION. INDEX.

GARDEN CITY NEW YORK
DOUBLEDAY, PAGE & COMPANY
1914

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MISCELLANEOUS FARM SUBJECTS

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PART I

FARM MANAGEMENT.

FARMING is a business and its measure of success depends upon the extent to which correct business principles and business methods are applied to its management. While the methods of farming must vary according to location there are certain principles of management that are applicable to all farms. Every part of the business of the farm should be conducted upon a well laid out system. The most successful system of farming is that which gives the largest profit, leaves the soil in condition to yield maximum crops, and brings to the farmer and those dependent on him the largest measure of happiness. In conducting a farm upon such a system, the farmer must continually answer for himself the questions: What crops shall I grow and what area of each? What care shall I give these crops and the soil upon which they grow? What disposition shall be made of the produce of the fields? If the crops are to be sold, then when and where? If they are to be fed, then to what classes of stock and to what number? What manures and fertilizers shall be applied to the soil, to what crops, in what season, in what quantities? What provision shall be made for the protection of growing crops from insect pests and fungous diseases, for storing crop products, for the protection and care of live stock? When and where shall live stock and their products be marketed? The repeated answering of these and other similar questions constitutes farm management—a business in which is found the application of many sciences, but a business so broad and complex that it must rest mainly on the accumulated experience of generations of those who have followed it. Conditions of climate, proximity to market, the character of farm labor, social conditions, and that great enigma, the soil, have all been determining factors in the development of the systems of farming that have been gradually evolved in the various sections of the country.—(Y. B. 1902.)

Arrangements.—A proper conservation of time and labor is an important feature of farm management. The arrangement of the fields and buildings may make a great difference in the time required to accomplish the work of the farm. The field arrangement must necessarily depend largely upon the topography of the land, but time and labor can be conserved even under the most adverse topography.

Buildings.—The buildings should be constructed from the point of view of economy in expense and time and for convenience in use. The horse and cow barns should be so located as to prove economical of time in getting to the fields. The wagon shed should be so constructed that the teams may be driven through the shed, saving time and labor in pulling or pushing the wagons into place.

Farm Plans.—It is often said that a farm can not be planned as other kinds of business are; that the vicissitudes of weather, the visitations of insect pests or plant diseases, the low prices that may prevail when the farmer has to sell, and other unforeseen circumstances may interfere to make all farm plans almost worthless from a practical standpoint. This is often quite true with reference to plans made for a particular year. But when the plans are based on average conditions for a long series of years, then the objections do not hold. For while it cannot be told what may happen during any particular season, it can be foretold with considerable accuracy what the average conditions will be over a series, say, of ten years. Plans for the farm must represent and be based on average conditions and not on single years. The farm plan must be made for a period of years and not for a single year. In replanning a farm it is essential that a few fundamental points in farming be kept constantly in mind: (1) The plan should provide a reasonable reward for the labor and capital invested. (2) The fertility of the farm should be maintained or increased. (3) The plan must be suited to the capabilities of the owner for carrying it out.

It is assumed that in order to replan a farm for profit it is necessary to consider the capabilities of the farmer to put the new plan into effect. This, in general, will render it necessary to recombine the phases of farming with which he is already familiar or to bring in new features which are not very dissimilar to the ones he is already accustomed to.—(F. B. 370 V; F. B. 432.)

Cropping System.—While the cropping system must depend largely upon soil, climate and proximity to market, it should be carefully planned so as to conserve the soil as much as possible. Where cereals are the principal crops, a system found to work admirably embraces corn, wheat (two years), grass for hay, pasture and corn.—(F. B. 432.) A short system is of wheat, clover and potatoes. This has several advantages. In the first place it is a short rotation, each of the crops coming once in three years on the same land. Then the potato crop is a strong money crop, the wheat a fairly good one, and the clover an excellent crop for maintaining fertility. Moreover, it is necessary to plow but once in three years. Perhaps the greatest difficulty with this rotation is that in some years the potato crop is so late in harvesting that it is not practicable to get the wheat in early enough to get sufficient growth to carry it safely through the winter, and the wheat crop is often light on this account. The clover is sown in the wheat in the spring and covered with a spike-tooth harrow. The first crop of clover is harvested and fed to the work horses and the cows. The second crop is usually mowed and left on the ground. This crop, together with the later growth, is plowed under in the fall. Potatoes are put upon this land the third year, the aim being to plant as early as possible in the spring so as to get a crop off in time for wheat.—(F. B. 454.)

In planning a cropping system the financial returns expected should take a prominent place. As an illustration, on a farm where a three-year rotation of corn, oats and clover has been adopted, the total average yields which may be expected after it is put in operation are about as follows:

Corn, 24 acres, at 60 bushels per acre	bushels	1,440
Oats, 24 acres, at 40 bushels per acre	bushels	960
Hay, 24 acres, at 2 tons per acre	tons	48

All of this produce can not be sold, however. The stock must be fed, and for this purpose it is assumed that the following quantities will be required throughout the year for the different kinds of stock:

	Pounds.
4 mares, grain fed, 15 pounds each daily	21,900
2 colts, grain fed, 1 pound each, 300 days	600
2 cows, grain fed, 4 pounds each, 180 days	1,440
Total	23,940

The figures given are averages. It is expected that the grain fed the heavy type of draft horses kept on this farm will average nearer 20 pounds during the busiest part of the working season and considerably less than 15 pounds in winter. Usually in winter, when but little farm work is going on, only one team will be fed grain. In the above estimates no account is taken of the hay fed to stock, as it is often the custom to use oat straw and corn stover as the only roughage either winter or summer.—(F. B. 370.)

An important feature of a correct cropping system is that the principal operations be performed on a fixed day each succeeding year or as near it as the weather will permit.

Conservation of Manure.—Not a pound of solid or liquid manure should be permitted to go to waste, if the wastage can be prevented. The method of conserving and handling manure on a model farm is thus described: The method can be used only on farms on which stock is kept in stalls, and it is therefore not applicable to all styles of stock farming; but it is so unique, so perfectly systematized, and bears such an intimate relation to the success attained, that an account of the farm would be incomplete without a full statement of it. Behind each row of cows is a gutter 18 inches wide and 7 inches deep. These gutters have no outlets. They are thoroughly cleaned daily. (The whole barn is disinfected twice a week by a free use of creolin, and the interior is frequently whitewashed.) When cleaned, the gutters are sprinkled with ashes or dry dirt to absorb what moisture may be present. During the day a quantity of absorbent, consisting of leaf mold, rotten sod, etc., is placed in them. Each gutter ends near a door. The manure is lifted from the gutter into a cart backed up to the door. The end of the gutter next the door is slightly lower than the other end. One man lifts the manure with a fork and places it in the lower end of the trench. A second man then lifts it into the cart. In this manner the liquid manure is all gotten into the cart. Finally, the fragments that remain in the trench are swept to the lower end and removed. The cart goes immediately to the field, and the manure is spread at once.—(F. B. 242.)

The materials named in the following table are more or less available on every farm, and it can be seen from the composition of each which are the most desirable.

Composition of Farm Litter and Straw and Its Value as Fertilizer.

Kind of straw or litter.	Nitrogen.	Phosphoric acid.	Potash.
	Per cent.	*Per cent.*	*Per cent.*
Wheat straw	9.6	4.4	16.4
Rye straw	11.2	5.1	18.1
Oat straw	14.4	3.6	23.0
Barley straw	11.4	5.0	23.5
Pea straw	20.8	7.0	19.8
Soy-bean straw	14.0	5.0	22.0
Buckwheat straw	13.0	7.1	24.2
Millet straw	14.0	3.6	34.0
Marsh hay	17.2	10.6	54.0
Leaves	15.0	3.2	6.0
Rice straw	15.1	5.2	8.4

—(Bu. Plt. Ind. B. 365.)

Successful farming is largely an adaptation of system to the conditions under which the farm is working. Unsuccessful farming is often due to a failure to make this adaptation.—(Bu. Plt. Ind. B. 64.)

The Garden.—The importance of the garden as a farm asset can hardly be overestimated. Ordinarily, in estimating a farmer's profits all fail to consider that the garden supplies a large part of his living. As a matter of fact, the farmer's income should be credited with the difference in the cash cost of running his family table and that of the man who has no garden. Yet the average farmer's garden does not receive the attention which it should have. All other farm work usually comes first and the garden is neglected. Most farmers will not take the time to care for the garden properly when it interferes with other farm work. Often not more than a few hours' work would be necessary to put the garden in proper condition, when lack of this attention would mean the purchase of vegetables or fruit. The farm garden is a real asset, a productive enterprise, and should be so regarded.—(F. B. 454.)

In order to give the maximum of efficiency a garden must be carefully laid out. A garden on a model farm is thus described: The garden, consisting of about 1 acre of land, is an important feature in the management of this farm. The crops are those planted in 1909. Besides the vegetables and small fruits for family use, the garden brings an income of about $200 a year, the products being exchanged for groceries. This pays the expenses of the table. The principal money crops from the garden are kale, spinach, winter onions (sold in early spring), tomatoes and cantaloupes. Kale and spinach are not common crops in this section and a ready market has always been found for them. Others, however, are beginning to raise kale on their own account, so that more spinach is now being raised on this farm. Prices have ranged from 40 to 60 cents a bushel for kale and 60 to 80 cents a bushel for spinach. From 250 to 300 bushels an acre is considered a good crop. Besides being raised for the market, kale is used as a general winter cover crop in the garden. It is found that kale plowed under in the spring puts the ground in fine condition for cantaloupes. A specialty has been made of raising late tomatoes to be put on the market when this fruit is scarce. Tomatoes are sold from this garden about the last of October and in November. Most of the products are sold by telephone to the merchants in the town and villages in the county.—(F. B. 452.)

The Orchard.—This is another feature of farm management. The fruit grown must depend upon soil, climate and proximity to market.

Seed Bed.—Having adopted a cropping system a most important feature of farm management is the preparation of the seed bed. Prepare a deep and thoroughly pulverized seed bed, well drained; break in the fall to a depth of 8, 10 or 12 inches, according to the soil, with implements that will not bring too much of the subsoil to the surface. The foregoing depths should be reached gradually if the field is broken with an ordinary turning plow. If a disk plow is used, it is safe to break to the above depths at once. It has been proved without question that the roots of plants penetrate the soil deeper and feed deeper in deeply plowed land. Thus, in general, it may be stated that when the soil is plowed 3 inches deep the plants have 3 inches of food, when plowed 6 inches deep they have 6 inches of food, and when plowed 10 inches deep they have 10 inches of food. The fact that the bottom portions of the plowed land are not as rich in available plant food as the top portions shows the necessity of getting more air and heat down to them by deeper tillage. The soil requirements most essential to the growth of plants are heat and moisture. Deep breaking insures air and heat at a greater depth. For plants to do their best there must be in the soil a constant supply of moisture, so that a film of water can envelope the soil particles and absorb nutritive elements. The hair roots of plants drink this for nourishment. If there is any more than enough to serve as films for the soil particles and capillary water, there is too much, and it should be drained off. This can be determined by digging a hole 20 inches deep. If there is standing water in the bottom of the hole, it indicates that there is too much water in the soil or subsoil. The capacity of a given soil to hold film and capillary moisture depends upon how finely it is pulverized and upon the amount of humus in it. Unplowed lands retain but little water. Thoroughly pulverized soil 3 inches deep can not store enough to make a good crop.—(Bu. Plt. Ind. B. 503.)

Subsoiling.—This operation is stirring the earth below the region of the plow. For convenience reference is made to the first eight inches of soil which may be turned over in plowing as the surface soil and all below this as the subsoil. Plowing turns the surface soil bottom side up. Subsoiling does not change the position of that part of the soil, but it breaks up and stirs the ground below the ordinary depth of plowing. This may be effected by a spur or prong attached to the plow which breaks up the soil at the bottom of the furrow, or it may be done with a separate implement to be drawn along through the soil beneath the bottom of the furrow after the plow, to stir the ground to greater depths than can be done with a small attachment to the ordinary plow. This implement is called the subsoil plow and usually consists of a mole or a more or less flat piece of iron pointed at one end and attached to the beam by a strong flat vertical blade. When drawn through the soil in the bottom of the furrow left by the plow this implement can be made to break up and stir the subsoil to a depth of from one to two or more feet.

The advantages claimed for subsoiling are that it makes more room for root development, and enables the plant to extract food and moisture from a greater area, and that by loosening up more of the soil its capacity for absorbing and retaining moisture is increased. By the absorption of greater amounts of moisture in winter and spring it is supposed that subsoiling provides against summer drouth. It is reasonable to suppose that this is what would happen and the many favorable reports on subsoiling from humid and semi-arid regions indicate that loosening the lower layers of soil is a valuable way of conserving moisture for those regions.—(Wyo. Ex. Sta. B. 41.)

Saving and Marketing.—The same systematic planning adopted as to the arrangements of the field and the determination of the crops should be followed in the marketing of the products of the farm. The proper determination of the crop to be raised is largely dependent upon the market, but successful marketing is a thing by itself. In many sections there are now community co-operation for the sale of the crops of its members. The preservation of the crop from loss or wastage after harvesting is a feature of correct farm management. In many places this is done by field coverings.

Every farmer should open an account with his farm, in which the farm should be charged with interest on the value of the farm, stock and equipments, and all items of expense in raising, harvesting and marketing the product, together with a fair allowance for deterioration and for the services of the owner. The farm should be given credit for all it produces, whether sold, fed on the farm or used by the farmer, together with a fair rental for the house. By this means the farmer will know each year whether his farm is profitable or not, and what the profit or loss may be.

CLEARING LOGGED OFF LAND.

Until recent years clearing was almost wholly done by what is now known as the by-hand method, where the farmer, equipped with peavey, mattock, shovel, and ax, undertook to put under cultivation the logger's stubble field. By this method the standing trees and brush were slashed, generally during the summer months. Then, in September or October, after the first rainfall or when there was no danger to neighboring improvements or timber, a fire was started and allowed to burn over the entire slashing, when most of the brush and small logs were burned completely. The remaining logs were sawed into convenient lengths, piled, and burned. After the rains had softened the ground sufficiently the smaller stumps and roots were grubbed and pulled out. Often a stump puller of the capstan type was used in pulling the smaller stumps after they had been loosened by digging around them.

This type of stump puller is often used in clearing small tracts after the stumps have been broken into several pieces and loosened by the use of stumping powder, without which no clearing is undertaken in the present day. The stump puller should be of simple construction, strongly built. It generally consists of a drum, a wire cable, and a sweep to which a team is hitched. Powder has been used in all clearing operations for several years, and all methods, except that of burning the stumps below the plow, are dependent upon it to loosen the stumps so that they may be taken out.

Donkey-Engine Method.—Some six or seven years ago when logs were down in the market and many logging outfits were idle, an enterprising logger took a contract for pulling the stumps from a meadow. He conceived the idea of using his donkey engine with its outfit of blocks and cables to pull and pile the stumps for burning. Since that time many such outfits have been engaged with varying success in clearing land. The usual method is to slash and burn over the tract to be cleared, in order to burn all the underbrush and as many small logs as possible.

Then all the stumps more than 1 foot in diameter are split and loosened by a charge of stumping powder of from five to twenty sticks, according to size. A charge of twenty 1½-inch by 8-inch sticks will generally split a 5-foot stump into five pieces and loosen it so that an engine can pull the pieces from the ground.

The first method of burning out fir stumps described below has been used by almost all farmers and others who have done any clearing in a small way. This method consists of boring two intersecting holes in the stump and starting a fire at the point of intersection by putting coals of fire or a piece of iron heated to a white heat into the upper auger hole. A window weight with a wire fastened in the eye makes a good iron for this purpose, as it can be taken out and used again and again.

After the upper portion of the stump has been burned away, the fire may be kept up by throwing in the bark and litter that are always to be found near by. By this means the main part of the stump is burned away, leaving the larger stringers with their smaller roots. These may be pulled out by a team or with a stump puller, or they may be entirely burned by digging away the earth and rolling a small log alongside of the root. This leaves but few small roots to be grubbed out by hand.

By this method the soil is but little disturbed, the subsoil is not scattered over the surface, and the ashes are left where most needed.

This method requires less leveling than where holes are made by the use of powder. It is said that one man can burn out thirty large stumps a week by this method and can cut up and pile the logs near by at the same time.

Another method of burning out stumps is to split the stump with a small charge of powder, which nearly always makes a large hole underneath and around the stump. This hole is then filled with kindling and other wood and fired. Of the remaining roots, those that lie near the surface are grubbed out, while the others are cut off to a depth of from 12 to 18 inches below the surface.

Charcoaling or pitting stumps, as it is called, is a method of burning out stumps that has been little used, but where tried has proved very efficient.

The bark should be removed from the stumps in the spring or early summer to allow the outside of the stump to become thoroughly dry. Often it is well to dig a trench around, or to level the ground near the stump; then a ring of wood is stood or piled closely about the stump to a height of 2 feet and 1 foot thick. Dry rotten wood or bark such as is found in abundance on any new land will answer the purpose. This is then completely covered with sod to a depth of several inches, except a small space on the side the wind is blowing against. Where no sod is to be found the wood can first be covered with a layer of bark, small brush, or ferns to keep the loose earth from sifting through. Fine kindling is placed in the open space and fire started and allowed to burn openly until the ring of wood is well afire; then a piece of bark or a bunch of ferns or grass is thrown over the hole and the sod covering completed. The stump must now be closely watched and the fire not allowed to burn through the covering, more sod being added as needed. The whole secret of burning the stump completely is to keep the covering intact. If the roots are kept well covered and are re-covered as soon as the earth caves, exposing them to the air, they will burn out completely. This method is very economical for large stumps. Small stumps can be grubbed or pulled out to better advantage. After ten days it will be found that the stumps require very little attention.

Use of Powder in Clearing Land.—At the present time few undertake to clear even a small tract of land without the use of powder, and in the hands of an experienced man powder can be made to do a large amount of work at comparatively small expense. The powder in general use at the present time is known as stumping powder and is put up in sticks of 1½ by 8 inches, about 65 of which come in a box of 50 pounds. The charge of powder is placed as nearly as possible beneath the center of the stump. The powder should be placed on the hardpan if the soil is not too deep; otherwise it is placed from 2 to 3 feet below the surface.

To get the best results the sticks are removed from the paper wrappers and packed closely together in the hole beneath the stump. This can not be done in wet places. The powder works best when the temperature is about 70° F. This powder has more effect when the soil is saturated with water. The wrappers are allowed to remain upon the sticks in wet places. The following charges will be found effective under average ground conditions and where using stump pullers or blocks and teams:

Diameter of stumps in inches	18	24	30	36	48	60	72
Sticks of powder	5	7	10	20	35	50	65

Where the soil is sandy and loose it will require one-half more powder for the same size stump. As this powder does not work well at a temperature below 70° F., it is necessary when using it in cold weather to keep it warm by some method. Some powder men bury the boxes in a manure pile; others lay it upon a perforated rack over boiling water. As in either of these methods the powder becomes more or less damp from the vapor it is thought that when dry heat is applied better results are obtained.—(Bu. Plt. Ind. B. 25; Col. of Wash. B. 93; Col. of Wash. B. 101; F. B. 381; Wash. Ex. Sta. B. 40; Univ. Wis. B. 216.)

THE TRACTION ENGINE IN AGRICULTURE.

The use of the traction engine in agriculture is rapidly extending. Its use in plowing is of comparatively recent date.

The opening up of vast tracts of level territory where the acreage to be broken was so great as to discourage the idea of turning it with single teams and horse plows created a lively demand for steam plowing outfits, and in this field more than any other have they demonstrated their practicability. Under favorable conditions the advantages are numerous. Large areas, which otherwise would have remained uncultivated, have been brought quickly into productiveness and have been cropped with a minimum of horse and man labor, which has constantly become more expensive. Crop returns have often been greatly increased through taking advantage of favorable soil and climatic conditions for getting the land in shape for seeding, especially in sections where these conditions are of short duration. Work at such times has been rushed, often continuing day and night. At other times, as in hot, dry weather, traction outfits have been used where horses could stand the work but a short period, if at all. Through concentration of power it has been possible to plow very difficult soils and to plow deeply, when desired, in ordinary soils.

Under favorable conditions the cost of traction plowing has been brought below that of horse plowing. Considering the total cost of prime mover, shelter, and incidental equipment, and the surplus of horses needed to keep a given number in the field, the investment in motive power is frequently reduced by the substitution of engines for horses in plowing, and maintenance during periods of idleness is greatly simplified.

Plows Used With Engines.—Practically all traction plowing is now done with specially designed engine gang plows. These may be divided into the disk and moldboard types, and the latter into steam-lift and hand-lift. Engine gangs present greater variation in type and adaptability than do engines, and this is an important factor in such success as the practice of traction plowing has had.

Variations in plow shapes, such as have been worked out for local conditions, apply as well to engine as to horse plows; hence the problem has been principally to combine plow units into large gangs in the most satisfactory manner.

Disk Plows.—Disk plows are popular with traction plowmen, as it is possible with them to cover more ground with a given expenditure of time and power than with moldboard plows. Furthermore, it is possible with them to plow a continuous furrow around a field without labor and loss of time in lifting plows at corners or headlands, though in this case the corners are usually left to be plowed out with horses. Disk plows, especially the smaller gangs, accommodate themselves readily to uneven surfaces and tend to roll over obstructions. They can be used under certain conditions where moldboard plows can not; yet it is doubtful whether, on the whole, they do as good work.

Engines.—Steam engines are much more common than gasoline engines for traction plowing. Steam engines used for plowing are usually rated at from twenty to fifty horsepower.

Traction Plowing.—No general statement as to the practicability of traction plowing can be made, as the factors involved are too many and too varied to admit of general conclusions, even for a single locality. Any one of the factors may determine the success or failure of an outfit. Many localities are generally unsuited to the practice, but a few operators may have remarkable success because of favorable environment or unusual ability. If season, soil, and topography are favorable and fuel and water are convenient it becomes largely an individual problem. The size and cost of equipment, the acreage to be plowed, the cost of operation, and the energy and ability of the operator are all important factors materially affecting any conclusions which may be drawn from averages.

Two widely varying points of view are encountered with regard to the practicability of traction plowing under any given conditions, namely, that of the landowners and that of the custom operators. The former have an interest in the crop beyond the mere cost of plowing the ground in preparation for it, and it is safe to say that the majority of these have decided the question on the basis of net returns.

Granting the practicability of traction plowing under given conditions, the selection of equipment, and especially of the tractor, is a vital point. Plows for this work are in the main satisfactory and, being confined to comparatively few makes, are more easily investigated. However, the large and rapidly growing number of traction engines offered for sale makes selection difficult. To be practicable the tractor must be powerful, durable, economical, and simple, with emphasis on all four points. It must draw a profitable load continuously while at work and that without excessive depreciation and repair charges. It must be economical of fuel and labor and not so complicated as to require skill not readily acquired by the average farmer. In addition to serviceability in plowing it should be adapted to a wide range of usefulness in order to compete seriously with the horse as a source of motive power.—(Bu. Plt. Ind. B. 170.)

Owing to the initial cost of traction outfits for plowing, owners of farms of from 160 to 500 acres may be deterred from their use; but by combinations among neighboring farmers this difficulty can be overcome.

POWER ON THE FARM.

Power is rapidly displacing hand and horse labor on the farm, and the use of machinery will continue to increase. Engines are now being used for pumping water for the home and for stock, and to supply irrigation; to operate creameries and butter factories, feed cutters, grinders, corn shredders, threshing machines, motors for plowing, mowing and reaping, electric lighting, etc.

Engine and Fuel.—The character of the engine and the fuel to be used are becoming important and serious problems to the farmer. The newest kind of fuel is alcohol. This is made from the yearly crops of plants, and it may be said, in a sense, to be possible to produce an inexhaustible supply. What fuel is the most economical depends largely upon the locality where it is to be used. The fuel most commonly used at present is coal and crude petroleum, but in many sections coal is expensive, and the supply of crude petroleum may become exhausted, so the substitution of alcohol is a matter of great consideration.

It is easy to understand how an engine may operate without understanding the well-known facts concerning explosive mixtures; but it is impossible to comprehend why engines should differ in fuel consumption or horsepower, good regulation, or any other characteristic without first studying in detail the influence of the mechanism on the composition of the explosive mixture.

Any fuel will burn when there is oxygen present in proper quantity and when the fuel has previously been heated sufficiently. This is true for any kind of combustion, such as the burning of wood, coal, oil in a lamp or cook stove, or gas issuing from an illuminating jet, as well as mixtures in exploding engines. When a fuel is mixed with air containing the right amount of oxygen, or mixed with any solid or liquid containing oxygen in the right amount, then explosive combustion is possible. If such a mixture be ignited at one point by heating it by a flame, a hot plate, or an electric spark, the combustion will travel through the entire mass of its own accord.—(F. B. 274.)

One fuel may furnish more heat units than another, yet the engine using the fuel supplying the lowest heat energy may have greater advantages for use on the farm. From the best figures obtainable it is possible to buy eight times as much energy for a given amount of money in the form of cheap coal as in the form of low-priced gasoline, or twenty-five times as much as in the form of high-priced gasoline or kerosene. This being true, it might seem to a casual observer as rather strange that gasoline should be used at all, and the fact that it is used in competition with fuel of one-eighth to one twenty-fifth its cost shows clearly that either the gasoline engine has some characteristics not possessed by an engine or plant using coal, which makes it able to do things the other can not do, or that more of the heat it contains can be transformed into energy for useful work. Both of these things are true.—(F. B. 274.)

Alcohol As a Fuel.—The efficiency of an alcohol engine may be assumed at this time to be unknown, but as alcohol can be burned in engines designed for gasoline, it may be assumed that such an engine will have with alcohol fuel the same thermal efficiency as with gasoline, to-wit, 19 per cent for fair working conditions.—(F. B. 274.)

If the alcohol engine can be shown to have an efficiency as high or higher than other liquid-fuel engines and be similar in type and characteristics, it can do all that they can do, and its field will be the same as their field in spite of fuel costs; but by field is meant the nature of the work rather than the geographical location. Should it appear that the alcohol engine can do more or better work than its oil or gasoline competitors, its field will be wider. In any case the position which the alcohol engine may take today is no criterion as to its future, because it will operate on a source of energy or fuel supply which is inexhaustible, whereas the supply of both crude oil and its distillates may ultimately become exhausted.

The determination, then, of the position of the alcohol engine today involves a forecast of the future, and should it be shown to be able to compete now it must inevitably reach a stronger and more important industrial position as time goes on.—(F. B. 274.)

There are other uses to which alcohol may be put on the farm. The most important of the uses of industrial alcohol as far as the farmer is directly concerned are those included in heating and illumination. For these purposes the farmers of the country, when the processes are adjusted and the technical difficulties of production, manufacturing, and denaturing are overcome, will find alcohol extremely useful. Especially will this be true in localities remote from centers of the production of wood, coal, kerosene, gasoline, natural gas, and oil, which now are the chief heating and illuminating agents.—(F. B. 269.)

Denatured Alcohol.—The difficulty that has stood in the way of alcohol coming into more general use on the farm has been the expense. The Congressional law permitting the denaturing of alcohol reduced the cost materially but it is still too great to admit of general use as a fuel. The Agricultural Department has conducted numerous experiments for the making of alcohol from farm refuse. On every farm there is much waste material out of which alcohol could be distilled, but not enough on any farm to compensate for the erection of a still. There is enough, however, in almost every neighborhood, if the farmers would co-operate, to justify the erection of a still. This would use material that otherwise would be wasted, and at the same time enable the farmer to procure a most excellent fuel at a cost that would actually prove an economy. A small still, large enough for neighborhood use would not require a very large investment of capital. The Agricultural Department has estimated that such a still could be erected in any part of the country at a cost not to exceed $12,000. The interest on this would be, say, $700. If enough raw material can be obtained from the neighborhood it might be operated at a reasonable profit. Co-operation among farmers is one of the questions of the present time, as it is among those carrying on business in the cities and towns, and a co-operation that will enable the farmer to dispose of what is now waste material so that it will bring him a revenue and at the same time enable him to procure a prime necessity at a smaller cost, is one that will commend itself to progressive agriculturists.—(F. B. 269, 469.)

The manufacture and sale of denatured alcohol for use in the arts and industries, and for fuel, light and power, is provided for by an act of Congress. Denaturing consists in adding to the alcohol certain substances that render it unfit and unsafe to be used as a drink or for the compounding of medicines. The substances specified by law for completely denatured alcohol are methyl alcohol and benzine in the following proportions: To every one hundred parts by volume of ethyl alcohol of the desired proof (not less than 180°) there shall be added ten parts by volume of approved methyl alcohol and one-half of one part by volume of approved benzine; for example, to every 100 gallons of ethyl alcohol (of not less than 180° proof) there shall be added 10 gallons of approved methyl alcohol and ½ gallon of approved benzine.—(Reg. 30, Bu. Int. Rev.)

Conclusions.—(1) Any engine on the American market today, operating with gasoline or kerosene, can operate with alcohol fuel without any structural change whatever with proper manipulation.

(2) Alcohol contains approximately 0.6 of the heating value of gasoline, by weight, and in the department's experiments a small engine required 1.8 times as much alcohol as gasoline per horsepower hour. This corresponds very closely with the relative heating value of the fuels, indicating practically the same thermal efficiency with the two when vaporization is complete.

(3) In some cases carbureters designed for gasoline do not vaporize all the alcohol supplied, and in such cases the excess of alcohol consumed is greater than indicated above.

(4) The absolute excess of alcohol consumed over gasoline or kerosene will be reduced by such changes as will increase the thermal efficiency of the engine.

(5) The thermal efficiency of these engines can be improved when they are to be operated by alcohol, first by altering the construction of the carbureter to accomplish vaporization, and second, by increasing the compression very materially.

(6) An engine designed for gasoline or kerosene can, without any material alterations to adapt it to alcohol, give slightly more power (about 10 per cent) than when operated with gasoline or kerosene, but this increase is at the expense of greater consumption of fuel. By alterations designed to adapt the engine to new fuel this excess of power may be increased to about 20 per cent.

(7) Because of the increased output without corresponding increase in size, alcohol engines should sell for less per horsepower than gasoline or kerosene engines of the same class.

(8) The different designs of gasoline or kerosene engines are not equally well adapted to the burning of alcohol, though all may burn it with a fair degree of success.

(9) Storage of alcohol and its use in engines is much less dangerous than that of gasoline, as well as being decidedly more pleasant.

(10) The exhaust from an alcohol engine is less likely to be offensive than the exhaust from a gasoline or kerosene engine, although there will be some odor, due to lubricating oil and imperfect combustion, if the engine is not skillfully operated.

(11) It requires no more skill to operate an alcohol engine than one intended for gasoline or kerosene.

(12) There is no reason to suppose that the cost of repairs and lubrication will be any greater for an alcohol engine than for one built for gasoline or kerosene.

(13) There seems to be no tendency for the interior of an alcohol engine to become sooty, as is the case with gasoline and kerosene.

(14) With proper manipulation, there seems to be no undue corrosion of the interior due to the use of alcohol.

(15) The fact that the exhaust from the alcohol engine is not as hot as that from gasoline and kerosene engines seems to indicate that there will be less danger from fire, less offense in a room traversed by the exhaust pipe, and less possibility of burning the lubricating oil. This latter point is also borne out by the fact that the exhaust shows less smokiness.

(16) In localities where there is a supply of cheap raw material for the manufacture of denatured alcohol, and which are at the same time remote from the source of supply of gasoline, alcohol may immediately compete with gasoline as a fuel for engines.

(17) If, as time goes on, kerosene and its distillates become scarcer and dearer by reason of exhaustion of natural deposits, the alcohol engine will become a stronger and stronger competitor, with a possibility that in time it may entirely supplant the kerosene and gasoline engines.

(18) By reason of its greater safety and its adaptability to the work, alcohol should immediately supplant gasoline for use in boats.

(19) By reason of cleanliness in handling the fuel, increased safety in fuel storage, and less offensiveness in the exhaust, alcohol engines will, in part, displace gasoline engines for automobile work, but only when cost of fuel for operation is a subordinate consideration. In this field it is impossible to conveniently increase the compression because of starting difficulties, so that the efficiency can not be improved as conveniently as in other types of engines.

(20) In most localities it is unlikely that alcohol power will be cheaper or as cheap as gasoline power for some time to come.—(F. B. 274, 277, 269.)

FARM EQUIPMENTS.

A part of the economy of successful and up-to-date farming is to have, in addition to the larger equipments necessary, an adequate supply of what may be properly termed "minor items," and in having all these minor items, as well as the larger and more expensive implements, of the best materials and of the latest and most improved patterns. Quality and not mere cheapness should control in the purchase of all items of farm equipment.

The larger and more expensive farm implements are frequently purchased by a combination of neighboring farmers, and their joint use provided for by amicable arrangement. This is an excellent plan, and should become more common among small farmers, now that the telephone has placed the farmers in quick communication with each other. In case one farmer must sell out and leave the neighborhood there should be an arrangement made by the others to take his interest off his hands at a fair compensation, reasonable notice having been given of the removal. This cannot be made to apply to the minor items of equipment.

Minor Items.—In selecting the minor equipment for a given farm, consideration must be given not only to the items needed for the care and repair of buildings, fences, machinery, etc., but to those used for the care of live stock, the production of crops, and various other interests of the farm. With every change in type of farm involving a new combination of enterprises a change in minor equipment will be necessary. For each of the many specialized types of farms certain articles will be needed which will not be found on the general run of farms.

The nature of minor equipment will be determined largely by the character of the farm enterprises and the distance of the farm from repair and shopping facilities, while the extent may be governed by the size of the farm, the number of workmen and the financial circumstances of the proprietor. Perhaps both will be influenced most by the latter's attitude with regard to small economies, and his ability to use tools to the best advantage.—(Ohio E. S. C. 98.)

Each branch or division of farm work should have its supply of tools or implements. Farmers on taking an inventory of what they have, frequently find they have duplicated some and are minus others that are of importance. By a little care this can be avoided. One advantage gained by having an adequate supply of these minor items of equipment is to save time and labor, and on the farm time is frequently of great importance. These minor items apply to the stable, the care of and keeping of all kinds of stock, the orchard, the dairy, all the crops, for marketing and for the repair shop. One of the most important is a complete assortment for repair work. The number and character of the small tools and other items necessary will depend upon the size of the farm, and the purposes of the farm; but there are many items common to all farms.

Selection.—The selection of the tool outfit will depend upon the scope and character of the work to be performed. On most farms there is a deficiency of suitable repair tools and supplies, and an increased investment along this line is strongly recommended. Some farmers, however, need to be cautioned against hasty, indiscriminate purchasers. A small, well selected outfit, used to the best advantage and well cared for, will prove more satisfactory than a large miscellaneous assortment improperly kept and used.

In nearly all localities most of the tools may be purchased from the local hardware dealer. In many places there are stores known as farmers' supply houses from which many of the more common tools may be purchased. In addition to these, many of the manufacturers of tools offer combination outfits, and the large mail order houses of the country are prepared to supply tools of all kinds, either singly or in combinations. A number of tools and appliances are not ordinarily found in the regular stores, and these can be made either by a local mechanic or on the farm.

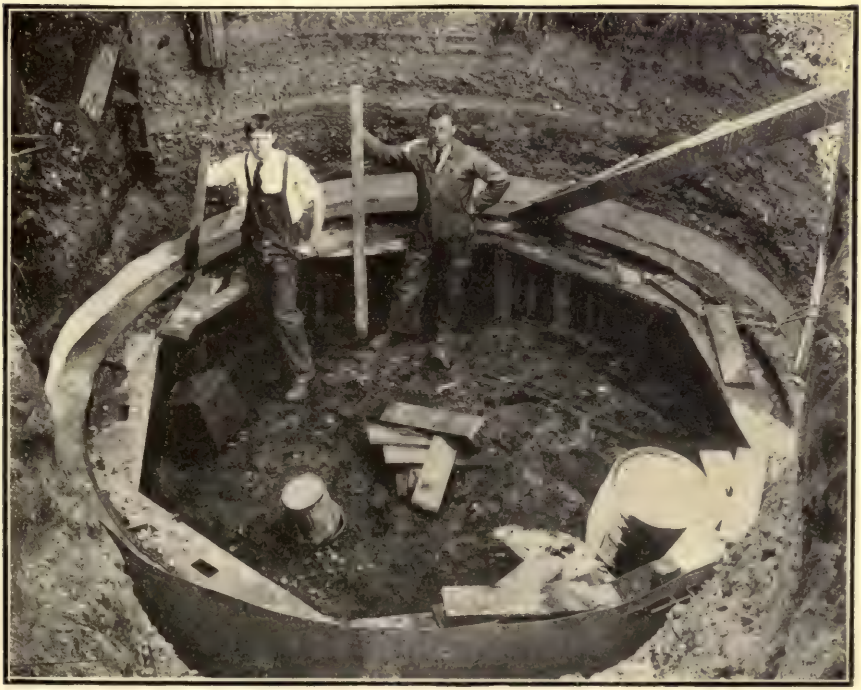
Under most circumstances it will pay to secure tools of good quality, although fine exterior finish is not essential. Tools of very inferior quality are offered at low prices, but they invariably prove a disappointment to the purchaser. The name of the manufacturer is a sufficient guaranty of the quality of many tools, and the purchaser is advised to secure only those that are sold under a guaranty from either the manufacturer or the dealer. When contemplating the purchase of a collection of tools, make a careful study to see just what ones are needed, then purchase all at one time, and a liberal discount can generally be secured.—(F. B. 347; Ohio E. S. C. 98.)

Character.—Among the implements needed on every farm may be classed: Ax, hand ax, hatchet, handsaws, compass saw, steel square, drawing knife, brace and bits, screwdriver bit, screwdriver, augers, jack plane, smoothing plane, wood chisels, claw hammer, claw bar, spokeshave, wood rasp, folding rule, chalk line, plumb rule, spirit level, riveting hammer, monkey wrench, solid or end wrenches, alligator wrench, pipe wrench, punches, cold chisels, files, forge, blacksmith's hammers, tongs, vise, drill press, ratchet drill, chain drill, twist drills, hack saw, soldering irons, thread-cutting appliances, pipe-fitting appliances, tinner's snips, small vise, dividers, crowbar or pinch bar, maul, or beetle, grindstone, oilstone, oiler or squirt can, wire stretcher, staple puller, leather punch, rivet set, workbench, sawhorses, and miter box.

Materials for Repair Work.—However complete the tool equipment, it will be of little use without a supply of materials with which to replace worn or broken parts of machinery and implements. The time required to secure stock materials may be as great as that necessary to have the repairs made in the nearest shop. A supply of timber, bar iron, bolts, rivets, screws, etc., should be kept constantly on hand and renewed from time to time as the stock runs low.

It should be the practice to save every small piece of good material and store it in a dry loft or other convenient place. A good piece of a thin board can frequently be saved from a broken packing box,

Students Raising the Frame of a Concrete Silo. Dept. of Agr.
(See pages 134–140.)



Students Constructing a Concrete Silo. Dept. of Agr.

and this will serve as well as new material for repair work. It should be the policy to save every good barrel hoop or extra barrel head for future use in replacing a broken or missing one. Very little time will be required to care for these articles if some system of storing them is employed.

The Care of Tools.—The system of storing the tools should conform to the needs of those using them and to the work to be performed. In many instances it may be desirable to keep the tools in a portable chest in which they may be carried to any part of the farm or plantation; on the other hand, if the work is done almost entirely at the shop the tools will be more accessible when supported on the walls or upon shelves above the bench.

In climates where the atmosphere is moist the greater part of the time, it is not wise to keep the tools exposed by hanging them on the walls or laying them upon open shelves, but a wall cabinet or a tool chest should be provided. It should be the aim to have a place for every tool, and then cultivate the practice of returning it to its proper place immediately upon the completion of the work in hand. A very good plan for keeping the tools in their respective places is to first draw an outline of each tool in its place upon the wall and then paint this space black or some color in contrast with the wall itself, so that when any tool is not in its place its absence will be readily apparent.

Many persons are in the habit of leaving tools where they finish using them. In the first place, a tool can not be kept in working condition if allowed to remain exposed to the weather, and in the second place the time lost in locating the tool when it is next required for use will be much greater than that which would be required to return it to the proper place.

The importance of having a good working equipment in small items, and the absolute necessity for caring for it, are matters which should be apparent to the thoughtful farmer. The waste of time in making numerous special trips for small articles is also apparent, especially so when it is considered that many of these occur in the busiest seasons. This could be avoided to a large extent by taking an inventory during a slack period and replacing all missing items at the next opportunity. Concerning the loss through ignorance of what is needed, however, less has been said, and it is to the requirements in miscellaneous items and the purchase thereof that this circular will be largely devoted.—(Ohio E. S. B. 98; F. B. 347.)

Educational Values.—The use of tools is of great value as an educational feature, especially when the work is carefully performed. The boys on the farm should be encouraged in the use of tools, and should be held responsible both for the care of the tools and the character of the work performed. The tool outfit of the farm is of special service on stormy days and will aid greatly in keeping the boys employed and contented to remain at home.—(F. B. 347.)

WATER ON THE FARM.

The quality of a water is, of course, only definitely known by chemical or other analysis, and yet common sense will be of great service in aiding one to select a proper source of water supply. No water is perfectly pure, and nature does not intend man to use chemically pure water, for certain salts and metals in solution are necessary for the human body. On the other hand, there are some kinds of pollution which are undesirable and even dangerous. The most common forms in which this pollution comes are in the form of lime or magnesia, which makes the water hard. There is no great danger in drinking hard water, so far as medical knowledge goes, although a person accustomed to soft water will probably suffer temporary discomfort on changing to the other. The chief objection to hard waters is in the large amount of soap needed in using them, the disagreeable effect of those waters on the skin, and the deposits formed by precipitation in cooking or in the laundry.

The proportion of matter ground water will have in solution depends upon the quantity of soluble substances with which it comes in contact during its passage from the clouds, through the air, and the soil, and the amount of soluble material plant roots will absorb as the water percolates among them. More important than the amount of matter dissolved in the water is the composition of the matter. The best evidence of the origin of the matter held in solution by the water is obtained by determining the amount of chlorine present. This element is one of the two which forms common salt, and is almost invariably present in a natural ground water. The proximity of cultivated fields will modify the amount of chlorine naturally present in a spring water, owing to the application of fertilizers. It is always safe to have a test made of the water before using it for household purposes.—(N. H. C. B. 53; Cornell Univ. Reading Course 29.)

To judge the healthfulness of a water after knowing something about the origin of its soluble constituents, the most stress is laid upon the relative quantities of four different compounds of nitrogen, an element occurring in all animal and vegetable tissues, as well as forming four-fifths of the atmosphere. It occurs in water in the form of ammonia, soluble organic matter and two classes of compounds, called respectively nitrites and nitrates. The ammonia in unpolluted spring-water is due mainly to the rain, which washes the atmosphere free of this gaseous substance, that escapes into it from every fire and every piece of decaying animal or vegetable substance. The ammonia present in water is usually spoken of as free ammonia in order to distinguish it from ammonia which the chemist obtains from the nitrogen in the soluble organic matter by means of suitable chemicals and called albuminoid ammonia. Ammonia and soluble organic matter containing nitrogen are rapidly changed in the soil by certain micro-organisms into nitrites and nitrates. These latter compounds, especially nitrites, are also formed in the atmosphere by electrical discharges and therefore occur in rain especially after or during thunder showers. Nitrites and nitrates are very necessary to the life of plants, however, and consequently, under natural conditions of soil and moisture, they will be absorbed by plant-roots as fast as formed. Hence unpolluted springs show no nitrites nor nitrates and only minute quantities of free and albuminoid ammonia. Heavily manured fields in the vicinity of a spring may cause the presence of nitrates and nitrites as well as an increase of chlorine in the water, because there is often a larger supply of them than the crops can handle, and they are easily leached from the upper layers of soil beyond the reach of plant-roots. Leaves or sawdust not uncommonly to be found in springs, are pretty sure to increase the amount of albuminoid ammonia above what it would be if the spring were clean.—(N. H. C. B. 53.)

If springs are depended upon, the spring should be properly cared for to prevent surface water from flowing into it, and keep out leaves and other rubbish. If walled with brick and concrete an excess of lime is likely to occur, and a high percentage of solid residue.

Wells.—Water from very deep wells which get their supply from strata of soil below the influence of local surface impurities show a difference somewhat in composition from the waters of unpolluted springs. Some wells as well as springs are seriously contaminated with iron, though the water is otherwise good. Such water is usually clear when freshly drawn from the well, but in exposure to the air it soon becomes opalescent, due to the changes taking place in the iron salts by which insoluble compounds are formed, sometimes ending in deposits of particles of iron rust. Such water is more unpleasant than injurious, being especially unsuitable for laundry use. The iron may, and usually does, come from iron salts in the rocks; but in some cases it is due to the use of old chain-pumps. In the former case it cannot be remedied, but in the latter can be, and ought to be.

Having been provided by nature with the best of ground water, what kind does the average farm household use for drinking and other domestic purposes? An examination of many farms will show that the well has been located with more regard for convenience than health. A common situation is within fifty feet of a sink-drain, a privy-vault, or a barn-yard, and sometimes the well is surrounded by all three. Usually a curb or embankment prevents any surface-wash from entering the well; but it does not appear to be borne in mind that a large part of the rain-fall soaks into the earth, carrying with it the soluble constituents of animal and kitchen wastes with which it came in contact on the surface, sooner or later to reach the well.

The waters from such wells have almost always been found to leave much larger amounts of solid residue than those from unpolluted springs, and contain a higher proportion of chlorine, because salt is abundant in all animal excretions and kitchen slops. The waters are usually hard, since lime is also an important constituent of animal wastes. High chlorine at a distance from the ocean, may be considered a sure indication of sewage pollution. The four forms of nitrogen compounds in these waters give a larger aggregate than in pure spring waters, but the relative proportions of free ammonia, albuminoid ammonia, nitrites and nitrates, vary widely.

They all come from animal and vegetable matter dissolved in the water, and show the stages of decomposition which such matter has reached. These stages depend upon the character of the soil and the amount of contamination.

Free and albuminoid ammonias are usually high where the soil either permits free pollution or hinders the oxidation of the organic matter. Nitrates are high when the soil favors the rapid oxidation of the organic matter. Consequently, waters containing much free and albuminoid ammonia arising from sewage, would be dangerous; but if the nitrogen were present only in the form of nitrates, the sewage would have been oxidized to harmless mineral matter. Nitrites being an intermediate stage in the destruction of organic matter are looked upon as suspicious constituents of water if not dangerous.—(N. H. C. B. 53.)

Care of Water.—It should be borne in mind that the well on any farm or any door-yard, cannot receive too much attention, for it supplies the water for household use, and on the dairy farm, for cheese factories, and for other purposes which are related to food supplies. Well water is most commonly contaminated in two ways; either by surface water running directly into the well, or by barnyard drainage, household slops, and cesspools. Sewage disposal may be so managed that it is not a menace to the water supply; one of the most satisfactory methods is by the employment or use of a septic tank, and this need not involve any great trouble or expense.

In many instances, reasonable care of the surroundings of the well would remove all danger from disease by the pollution of the water. Privy-vaults should be made water-tight, well ventilated, and frequently supplied with dry earth. Nature has provided abundance of micro-organisms in feces and in soil that with plenty of air and little moisture will rapidly change all soluble organic matter into harmless gases to be dissipated in the atmosphere. The sink-drain should be carried as far as practicable from the house to a lower level than the bottom of the well if possible, and discharged upon the surface of the ground. The sun will help disinfect the sewage and if rank plants are encouraged to grow on the spot during the summer, there will be little percolation to the ground-water.

A cess-pool should never be used in the vicinity of any well or spring; a pit in the earth, from which the water, saturated with soluble filth, slowly seeps away, furnishes practically no chance for the purification by the soil organisms, because they act weakly or not at all, at depths of two to three yards below the surface of the earth. The economical handling of manure and garbage by composting in cemented cellars or sheds, where leachings cannot escape, will prove both pecuniarily and healthfully superior to the careless treatment usually given those substances.

On many farms a supply of water can be obtained from a source remote from any danger of contamination, and the substitution of such a source for the farm-well is the best means of receiving good water. When a spring is lower than the farm-buildings, careful attention should be paid to the direction in which the drainage from them would naturally flow. A pond or stream is seldom suitable for a family supply because its drainage-basin is usually beyond the control of any single farm. A tight cistern connected with clean roofs furnishes a safe source of supply if the cistern is kept clean.—(N. H. C. B. 53.)

Diseases in Water.—The question may be asked, What is the specific effect on the human system of these substances which occur in drinking water? It is the opinion of physicians, that many cases of general debility and of bowel troubles may be ascribed to water polluted by sewage. The latter complaints are especially apt to occur in individuals who are newly subjected to such water, after being accustomed to good soft water. This fact makes especially emphatic the necessity of pure water on farms that accommodate summer visitors from the cities.

The greatest danger in the use of sewage polluted water, is the possible presence of the bacteria which cause typhoid fever. These germs of disease cannot exist for any length of time in good spring waters, because there is too little matter for them to feed on; but polluted waters furnish the necessary conditions for their maintenance in the products of decomposing organic matter, and they may live in such water several weeks, ready to poison some person obliged to drink it. Of course, all waters showing high proportions of chlorine and ammonia do not contain disease germs. It is commonly assumed that the soil acts as a filter on water and removes all dangerous matter as the water passes through it, but repeated trials by sanitary experts have shown that neither earth nor any other common filtering material will remove disease germs from water unless there is a thorough destruction of the soluble organic matter, thus depriving them of food.—(N. H. C. B. 53.)

Nearly all of the bacterial life exists in the upper strata of the soil. Soil ten or twelve feet below the surface of the earth is perfectly sterile, unless it has within it a crevice or opening so that surface sewage can run down. Therefore due care should be taken in digging and constructing a well so that direct contamination will be prevented.

Well Construction.—The well itself must be so constructed that the impurities can not get into it from above or from the sides. Water should be filtered through ten or twelve feet of fine soil. To prevent the surface pollution a water-tight wall should be built in a well down below the water level. This can be built of hard, burned brick and cemented on the outside. Clay should be pounded around this.

Where drilled wells are used the lining of the well should be an iron tube driven into the bore and the outside should be flushed with thin cement. The well should be properly covered and the surrounding ground should be considerably higher than the general level of the soil. No well should ever be located down the hill from filth heaps. The walls should extend at least 3 feet above the surface of the ground and a ground fill made so that it will slope from the wall. The top of the fill should be covered with at least twelve inches of clay or loam, upon which it is advisable to have some sod or a layer of sand or, best of all, a pavement sloping in all directions.

If due precautions are taken in the disposal of sewage, care of waste and garbage, and in the proper construction of wells, there is little danger of well water becoming polluted. An abundant supply of pure water is a great step toward insuring the health of the household dependent upon the well, and increasing the wholesomeness and healthfulness of the butter, milk, cream, and other products sold from the farm.—(N. H. C. B. 53.)

Table Use.—Pure water for table use is essential to health. Clean water coolers, pitchers, water bottles, drinking glasses and pure ice should be used. Many persons overlook the first requirements of an attractive table in this respect, and also are exceedingly careless of the water and ice supply which to a very great extent menaces the health of the household. Water may be clear, cold, free from odor and taste, and yet be unfit for drinking purposes, because of bacterial contamination from sewage or other causes. In the same way ice may look clean, yet contain very objectionable matter, including micro-organisms.

Where water may be contaminated in any manner, a simple way of removing the contamination and making it useful for drinking purposes in the household is to boil it. After being boiled it should be covered and allowed to cool. Many persons object to the use of boiled water and insist that it has a flat and unpalatable taste. Fresh water owes its sparkle to the air dissolved in it, and the flat taste of boiled water is due to the fact that the air normally present in drinking water has been almost entirely driven out by heat. If fresh water is boiled for a short time only, it retains more or less of the air dissolved in it, and when properly cooled is by no means unpalatable. A few minutes of vigorous boiling is sufficient for safety, and a few minutes of vigorous shaking will remove the "flat taste."

Water properly distilled is free from harmful impurities and is very satisfactory for household use. Boiled or distilled, or other water which is practically satisfactory for drinking purposes is frequently contaminated by adding dirty ice or by keeping it in a water cooler which has not received proper attention. If there is any doubt as to the purity and cleanliness of the ice supply, it is advisable to cool the water in receptacles placed near the ice, or in some other way so that the water is out of actual contact with the ice.

Under favorable conditions the process of freezing is undoubtedly a process of purification. Under ordinary conditions, however, contaminated water will produce an impure and unsafe ice. Ice is generally handled in a manner which is not conducive to cleanliness and should be carefully washed before using in water intended for drinking.

A great many persons who are very careful to secure pure water for their table do not exercise the same precaution with water used in their kitchens for cooking purposes for washing vegetables preparatory to cooking, and lettuce and other foods which are eaten raw, yet such precautions should be exercised. Experiments have demonstrated that butter washed with sterile, or pasteurized water, keeps much better than if washed in ordinary water.

Cisterns.—A well built cistern, carefully looked after, is probably the best water supply the people of some sections can obtain. No contamination can get into this supply except through the top of the cistern, and if the top is kept closed tightly, any other contamination must come through the down spouts from the roof. If the first water from every rain is not allowed to run into the cistern and the water which is caught is made to pass through a cleanable screen, made of fine wire gauze, the cistern will be kept in a good, pure condition. Where cisterns are used, all birds should be discouraged from congregating about the home; they will pollute any cistern. Some kind of pump, preferably a chain bucket pump—since it tends to prevent the woody taste that is characteristic of rain waters—should be used to draw the water. Drawing water by means of a rope and bucket will introduce filth, and the cistern must be opened, and, at times, will be negligently left so. The cistern should be cleaned out occasionally.—(Okl. S. B. 67.)

In alkali sections of the country it is frequently difficult to get potable water except by distillation.

Ice for Household Use.—The purity and wholesomeness of the ice supply has become very important because of the increasing use of ice for many purposes in the farm house. The consensus of opinion is that natural ice formed to a reasonable depth is comparatively pure under ordinary circumstances, but that it is very likely to be contaminated if it freezes to the full depth of the shallow pond, or stream, or if it is flooded with surface water. In general there are a great many conceivable ways that ice and ice supplies may become affected. The danger from many of these causes of infection may, however, be so remote or so infrequent as to hardly merit notice. There are, however, a few dangers associated with the formation of natural ice and the harmfulness of ice supplies as now generally practiced. The first of these dangers is the one due to the harvesting of ice from polluted sources. This ice may be taken from ponds or rivers which have been polluted by sewage and may contain the germs of typhoid fever and other diseases. Secondly, ice may become contaminated during the period and operations of harvesting by filth which may have come from infected sources. The hands and feet of laborers or the hoofs of horses may be channels by which infection may be transmitted to the ice even after it has been taken from the water, and notwithstanding the purity of the water. Thirdly, ice may become infected from surface drainage from the adjacent lands during thaws. The water which has flowed over infected fields that may have been fertilized or otherwise infected may be carried onto the ice and settle and be frozen into it. Finally, ice may become infected from the exposure and handling incident to distribution of it. This may be by far the most serious mode of infection, for it leaves the time interval between infection and transmission too short for any counteracting influence of cold to be exerted.

The opportunities afforded for infection during the distribution of the ice supply are many. They start with the infection by the icemen handling the ice and include infection from the dirt and filth gathered while the ice is deposited; the dirty ice broom, the water with which it is washed, and, finally, the handling just prior to placing in coolers or ice chests. To be sure, these sources may be largely avoided and wholly eliminated by final and careful washing, but here, as in all daily habits in the preparation of food, sanitary precautions are not always observed, and the dangers may often be more real than apparent.—(N. H. Col. Bul. 53.)

Notwithstanding there are many possibilities of ice infection, investigations of the subject show that the number of diseases attributable to ice is small. The reason for the small mortality from ice infection is due to a series of natural agencies or safeguards which tends to a process of successive eliminations, to reduce or entirely destroy the bacterial or germ life that may have been ordinarily present in the polluted water, or have infected the ice after its formation; perhaps the greatest influence in the self-purification of ice is the effect of low temperatures upon the life of the bacteria. Bacteria exposed to low temperatures near the freezing point very soon lose their vitality, and if exposed for a sufficient length of time are either killed or become so attenuated as to be practically harmless. Generally farmers do not put up ice nor use it during the warm months, but there is not a farmer in the land that would not like to have it, can have it at light cost, and should have it as a matter of comfort, of use in case of fevers and of health. All that is necessary is to co-operate, build a house, put up the ice when the time is not needed elsewhere, place it under the care of a member who would keep an account of the quantity used by each member. Do it.

METHODS OF CULTIVATION.*

Methods of cultivation vary between different sections of the country, and between individual farmers in the same section. No hard and fast rule can be applied as climatic and soil conditions, as well as crop systems must largely govern.

Fallowing.—The losses of nitrates from soils are greatest from wheat harvest to spring sowing, and least during the summer months. This fact teaches a most important principle, i. e., that ground should be kept in some crop as much of the time as possible, especially during the fall and winter.

Corn land should never be left fallow through the winter. The same is equally true of tomato and trucking land. Either these crops should be followed by wheat, or some cover crop put in to conserve nitrates. Of the latter there is none better than the well-known crimson clover.

In some sections especially in semi-arid regions summer fallowing is pretty generally the rule. Three reasons are usually given for the system: (1) To conserve moisture; (2) to eradicate weeds. The weeds rob the growing crops of both moisture and plant food. (3) To get the soil into such condition that it will produce satisfactory crops. In some sections late plowing with no cultivations is followed; in others, early plowing with summer tillage is the rule. Still another method of summer fallowing is what is known as Right-lapping..

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* For illustration, see page 420.

Late Plowing With No Cultivation.—This method is practiced most frequently where there is considerable rainfall. The land is plowed just as late in the spring as possible, and no further cultivation is given. The object in plowing so late is to get all the pasture possible before plowing and to have the soil break up in a cloddy condition and become so dry before it is plowed that no weed seeds will germinate. If no weeds come many think that plowing is all the cultivation that is necessary. Cattle and horses, and in some instances sheep, are pastured on the summer fallow to keep the weeds down. Many do this class of work because they are farming two or three times as much land as can properly be handled with their equipment. Others profess to believe in it. If the rainfall is considerable and is well distributed through the growing season, good crops are often secured by this method. The advocates of this system say it is desirable to have the ground pass through the winter rough and cloddy in order that the depressions may catch the snow and rain water and prevent it from running off the surface. They further say that the soil runs together and becomes closely packed during the winter if it is finely pulverized, and that the lumpy condition secured by late plowing with no subsequent cultivation largely prevents this.

There are some serious objections to this system of summer fallowing. In the first place, it is not conducive to the conservation of moisture, to desirable bacterial life, and to the decomposition of the organic matter in the soil. Instead of being freed from noxious weeds the soil constantly becomes more foul. The average yield of wheat for a number of years when raised on land summer fallowed in this way is probably from 5 to 10 bushels less to the acre than that secured on well-tilled land. It is also claimed that the yield of the spring crop that follows the winter wheat grown on land summer fallowed in this way is also usually very low.

Early Plowing With Summer Tillage.—This is a very common method of summer fallowing. The plowing is done in the spring as early as the ground is in good working condition. Some follow the plow closely with the common tooth-harrow. This settles the soil, pulverizes and dries the surface, and prevents the evaporation of a great deal of moisture. Others plow large areas before harrowing, permitting the soil to lie loose and open, just as the plow leaves it. In this loose open condition the air circulates through the soil too freely and dries it out very rapidly. Although it is not always done, it is usually the aim to do enough cultivating after plowing to control the weeds.

Right-lapping.—Where this system is followed the right-lap cutaway harrow is used. As soon as the spring seeding is done the land to be summer fallowed is cultivated with the right-lap. If there is no seeding to be done, this first cultivation is given just as early as the condition of the soil will permit. During the first cultivation the disks of the right-lap run about 4 inches deep. It will be seen that weed seeds are not covered too deeply to germinate. By the time the first cultivation has been completed—from four to six weeks—a crop of weeds has usually made its appearance on the ground first gone over, and it is necessary to begin the second cultivation immediately. The disks being large and set at a considerable angle will run from 5 to 6 inches deep and turn the soil and cover weeds quite well. This second cultivation usually destroys a good crop of weeds.

Usually two cultivations with the right-lap is all the cultivation given. However, if weeds come again, some use the right-lap the third time. Others use the harrow, slicker, or some other form of weeder.

Discing before plowing is often resorted to. Just as early in the spring as the ground is in good working condition the land to be summer fallowed is disced. Some disc but once, while others double-disc and then use a smoothing harrow. Most farmers concede that the more cultivation given the better.

There is much to commend this method. The discing and harrowing in the early spring before plowing form a loose mulch on the entire area to be summer fallowed much more quickly than it could be plowed. This saves a great deal of moisture, for the land plowed last often becomes very dry when plowing is the first operation.

Most weed seeds germinate best if not covered very deeply. When lying on the surface of the ground, the plow often covers them so deeply that they do not germinate until turned up near the surface again by subsequent plowing. Early surface cultivation covers these seeds lightly and gives them a chance to germinate before the plowing is done. The plow then destroys a crop of weeds, usually a heavy one. In this way practically all of the weed seed of the previous season's crop may be germinated before plowing and a clean surface soil turned under.

Early surface cultivation also causes the soil to plow more easily, and makes it more mellow and freer from clods. This is especially noticeable where roads have been made through the fields in the fall in hauling out the grain. Some farmers have formed the habit of harrowing these roads in the early spring, having learned its value accidentally by dragging the harrow to and from the fields. A great deal of trouble is experienced in plowing land covered with heavy stubble. Discing before plowing breaks the stubble down, partially covers it, and gets it into such condition that the plow turns it under much better than if the discing had been omitted. If the plowing is not delayed too long it turns up moist, mellow earth. The immediate use of the harrow is to settle and pulverize the soil. This condition of the soil is favorable to the conservation of moisture and the germination of the weed seed turned up by the plow. Later cultivation destroys this crop of weeds and helps to retain moisture. The more moisture retained in the soil while fallowing the greater will be the decomposition of the stubble and other organic matter. Chemical action in the soil is also favored, thus providing more mineral plant food.

It will be seen that practically all of the soil turned by the plow can be cleaned reasonably well from weed seed. The thorough cultivation before plowing cleans the surface soil before it is turned under, and the subsequent cultivation cleans that which is turned up to the surface. In this way a clean seed bed is obtained. Men who are using this system say that land badly infested with wild oats can be cleaned reasonably well in this way by two years' summer fallowing, raising one crop of wheat in the meantime.

A few farmers make a practice of discing land in the early autumn that is to be fallowed the next summer. Were this to become a common practice it would be a valuable addition to the present methods. By early fall discing weed seeds are covered and caused to germinate, the soil is put in better condition to take the winter rain and snow, and stubble is covered, or partially so, and its decomposition hastened. The soil usually works much better in the spring, and less surface cultivation is needed before plowing.

Where wheat is grown continually alternating with summer-fallow, removing the greater part of the straw with combined harvesters or by burning or otherwise, the humus supply of the soil is gradually reduced because the small root system of wheat and a scant stubble will not return enough humus to replace the amount that decays during the growth of one crop. This deficiency is becoming evident in many places by the soil puddling or running together in winter, baking worse, working harder, washing worse on slopes, and crops looking lighter colored and making less vigorous growth. To avoid this condition work as much straw and stubble as possible into the soil. Burn no straw and waste no manure. Scatter thinly over the poorer parts of the fields. Chop it into the soil with a disc harrow. The cutaway types seem to do the best work. If chopped in in the fall the winter precipitation will beat the loose soil and broken straw down so that the straw will begin to decay with the first warm weather of spring and will plow under with little danger of drying out the soil. The evil results so commonly attributed to plowing under long stubble or straw result from plowing it under unbroken so that it forms a layer between the seed bed and the moist soil beneath. Much of the straw sticks out between the furrows, furnishing most effective ventilation to dry out the soil beneath.

Stubble land to be summer plowed for summer fallow should be mulched as soon as the soil is fit to work in the spring by discing if the surface is pretty firm or with a spike tooth harrow if the surface is in condition to be loosened satisfactorily with it. The mulch need not be deep, but should form a continuous blanket over the surface. A disc set to gouge little creases in the soil with three or four inches of unbroken surface between does very little service. If the surface breaks up in slices or lumps, as it frequently does, the disc should be followed with a spike tooth harrow to pulverize the lumps and form a more perfect mulch. While it is vital that discing begin as soon as the soil is fit to work, it is a mistake, particularly in heavier soils, to begin when the soil is so moist as to slice up in cheesy chunks.

The practice of alternate cropping and summer fallowing is a common one in the semiarid region. Where this is done the land is kept thoroughly tilled during the year of summer fallow so as to store up the moisture of two years for the use of one crop. The value of this practice of allowing the soil to remain bare during the entire season is questionable, for, though it may serve to give good results for a few years, it must necessarily result in an almost complete destruction of the organic matter in the soil. This will bring about such a physical condition of the soil that it will no longer retain moisture as it did when it contained an abundant supply of organic matter.

A much better practice is to raise some kind of a leguminous crop which can be turned under before it becomes hard and woody and while there is still a sufficient amount of moisture in the plants and in the soil to cause rapid decomposition. The physical as well as the chemical composition of the soil will be improved by this practice instead of injured, as is the case where bare summer tillage is practiced.

Winter Tillage.—Not only is it important to keep a well-established dust mulch on all cultivable land throughout the summer, but effective measures should be taken to catch and hold all the moisture possible that may fall during the winter. In cold climates, where the soil remains frozen, but little tillage can be given. The south, however, is comparatively warm in winter, so that much soil moisture may be lost by evaporation unless the ground is harrowed or cultivated so as to establish a dust mulch after rains.

The usual method is to stir the surface of the ground as soon as it can be worked after each rain. Winter harrowing of fallow land may seem to be an expensive operation, but in the South it is very likely to make the difference between success and failure, and the expense is really not very great where proper tools are used.

Deep or Shallow Plowing.—The depth of plowing must be determined by the farmer himself. He knows the conditions and is the best judge of the cost. In many sections, if done in the fall, it undoubtedly pays to subsoil 15 or 20 inches. The advice to go down gradually is given solely because the inexperienced farmer may try to plow too deeply the first time and bring to the surface too much of the subsoil. The best plan is to use the disc plow, so set that it will not bring the subsoil to the surface. Generally it may be sent down 8, 10, or 12 inches with impunity, and, if done in the fall, with slight addition to the cost of shallower breaking. Double plowing—that is, to break at the usual depth and then follow in the same furrow with a narrower plow or scooter and go down as deep as desired—is better than shallow plowing, though a little more expensive plan than the use of a disc plow and not so effective. There is no question that breaking and pulverizing to a depth of 8 to 10 or 12 inches and adding plenty of humus is economical. Whether a plant has plenty of food all the time or only part of the time makes the difference between a good crop and a poor crop. Concretely stated, a deep, thoroughly pulverized seed bed filled with humus has the following advantages:

(1) It provides more food, because it increases chemical action and multiplies bacterial life in a larger body of soil.

(2) It stores more moisture and it loses its moisture less rapidly on account of its cooler lower strata and the presence of more humus.

(3) It increases the number of roots that a plant will throw out.

(4) It allows plants to root deeper and find permanent moisture.

(5) It largely obviates the necessity of terracing, because it holds so much water in suspension that heavy rainfalls will go to the bottom and be held by the drier earth above until they can be absorbed by the subsoil.

(6) Humus enables the soil to store more moisture, increases its temperature, makes it more porous, furnishes plant food, stimulates chemical action, and fosters bacterial life.

Exceptions to General Rules for Deep Fall-Plowing.—(1) Never plow below the line of standing water in the soil, because the subsoil can not be pulverized in water. The water level must first be lowered by drainage.

(2) Do no deep fall-plowing on light sandy land or dry, semi-arid plains, and this especially applies to elevated sandy table-lands and most of the deep sandy lands of the South. Such lands can be helped by adding humus and using a winter cover crop.

(3) The object of deep fall-plowing is mainly to increase the supply of plant food and the storage of moisture in the soil. While this preparation is of great value on rolling lands and nearly all fields so long in cultivation that plant growth is medium or less, there are some soils that for the production of cotton better not be deep fall-broken, such as very rich and moist river bottoms and the virgin black-land prairies of the Gulf States, for the evident reason that there is too much plant food for cotton already available in the soil, with abundant moisture—conditions that make for an excessive growth of the cotton stalks and a consequent decrease in fruitage—even under ordinary conditions. For the cotton crop upon such lands it is better to plow very shallow in the spring and bed upon the firm soil.

(4) Do not plow deeply or subsoil in the spring. The subsoil is generally too full of water, and it is too late for much effective action of the air upon the soil and for the winter rains to firm the subsoil before planting.

When Should This Plowing Be Done?—Always plow in the fall before the winter rains set in. Always use a cover crop of oats, barley, wheat, rye, vetch, or crimson clover, if possible. Every observant farmer has noted that seeds germinate more quickly and that plants grow more rapidly on fall-breaking than on spring-breaking. Fall-plowing renders more plant food ready for use, while the preparation of the land in the fall saves work in the spring, when everything on the farm is crowding. A cover crop is a net gain. It keeps the soil from washing, it utilizes the plant food that otherwise might escape into the air, and it adds humus. The soil is improved by the crop, and winter grazing is provided. In plowed land properly handled the loss of plant food is less than in unplowed land; more plant food may be produced and more can be stored. In case a cover crop is used the loss of plant food is slight.

An objection is sometimes urged that fall-plowed soil becomes saturated with water during the winter and remains wetter and colder later in the spring than land left unbroken in the fall. This is true only upon land not sufficiently drained and where the breaking is shallow. Water passes through deep breaking readily, and with reasonable drainage it is ready for planting earlier than lands broken in the spring.

With deep breaking and an abundance of humus it will be possible to dispense with many terraces and yet have no washing of the soil. Terraces are seldom required on the steepest hillsides of the North. Deep freezing opens the soil for the absorption of the rain. When land is nearly level, with a stiff subsoil, it should be flat-broken, but left in ridges or narrow lands about 5 or 6 feet wide, suitable for planting, with a dead furrow between. This provides winter drainage and keeps the pulverized soil out of the water, which is important even if unbroken.

Faulty Methods of Cultivation.—Some of the methods of cultivation, while effective in killing weeds, are not the best that could be used for the conservation of soil moisture or for controlling the movements of water-soluble salts in the soil, and are often positively harmful to the crops growing upon the ground. One of the methods is the common practice of running the plow close to the row, throwing the earth away from the plants, and leaving the furrows open one or more days. When this practice is followed, if the crop has reached considerable size, with ample leaf surface and strong root development, and if the weather is hot and drying and the soil moisture at all scanty, the crop is quite certain to show the bad effects of this method of cultivation, by the curling of the leaves, as a result of cutting off all roots on the side of the row to the depth the plow has run; and the injury is often so marked and great that it is distinctly recognized that the cultivation must not be done on both sides of the row on the same day. The loose soil thrown into the middle of the row soon loses most of its moisture; the sides of the furrow next to the row and the bottom also dry out very rapidly in the hot sun, so that when the furrow is turned back it is filled with a layer of dry, loose earth, into which new roots must develop to take the place of those cut away; and on top of this layer of dry earth is deposited the moist soil of the second furrow, which in turn loses its moisture rapidly, as does the firm surface of the bottom of the new furrow. It often happens that before new roots have had time to develop into the loose soil formed by the plowing the same operation is repeated on the opposite side, and thus the crop receives a very severe check to its growth by the double root pruning which this form of cultivation effects.

For many crops it is quite certain that the flatter cultivation, instead of the ridge-and-furrow form so much used, would better conserve the moisture and permit the rains to penetrate the soil more quickly and evenly, with less surface drainage and correspondingly less waste of soil fertility. With the distinct ridge-and-furrow cultivation the bad effects of rainfall are intensified if it comes at all rapidly, as then it is quite completely shed into the furrows, where it is forced to cover less than half of the available area of the field, and thus becomes equivalent to a rainfall of more than double the actual amount in its tendency to wash and to float away the organic matter and finer silt, and to dissolve the water-soluble salts of the soil which have accumulated over the whole field by evaporation. The deep, flat cultivation, with many shallow, narrow furrows to draw the water, still leaves ridges, through which the soil air may escape as the water enters by percolation from the bottoms of the furrows, thus facilitating a more rapid percolation, which thus holds the water at less depth in the furrows, forcing it to flow more slowly and greatly reducing its carrying power, so that washing is less marked.—(Y. B. 1905; Y. B. 1907; Y. B. 1909; Bu. Plt. Ind. B. 13; Wash. Exp. Sta. B. 15; Bu. Plt. Ind. B. 68; F. B. 294; Del. Col. B. 40.)

UTILIZING FARM WASTAGE.

Under the old system of farming much material that is valuable for feeding or fertilizing was left unutilized. Under modern and improved methods the farmer utilizes everything possible. In some sections many farmers engage extensively in the cultivation of peas and beans for canning and commercial purposes. At first the refuse of the cannery—the pods and vines—was let go to waste. Recent experiments have demonstrated that this refuse is valuable both as a forage crop and as a fertilizer.

Pea-Vine Silage.—The most popular method of using pea vines is as silage, and where the cannery is located in a dairy section this is almost universally the system in practice. The same treatment is also true for some of the sections where sheep and cattle feeding are popular industries.

There are two ways of making silage from pea vines, i. e., in large stacks and in silos. The practice of putting the vines in large stacks is the one most commonly employed, especially where practically all the vines from a cannery are handled by the canner or by one or two other persons. At many factories it has become a custom for the canners to put the vines up in stacks or silos and either to sell the silage to farmers and feeders in the winter or to buy stock and feed it out themselves, thus realizing a profit on what was formerly a waste product. At other factories one or more farmers or stock feeders will contract to keep the refuse vines cleared away for what they can get out of them. Still another practice is for the farmer who brings a load of peas to the factory to take home his quota of vines, just as the dairyman takes his load of whole milk to the creamery and then takes the separated milk home to feed.

The silage made from the refuse pea vines is generally regarded as possessing a high feeding value for dairy cows and other animals when a succulent feed is desired. There is some difference of opinion, however, regarding its value as compared with corn silage. Most dairymen who have had extensive experience in feeding both are of the opinion that the pea-vine silage produces a greater flow of milk than does corn silage. On the other hand, a few contend that when a change is made from corn silage to pea-vine silage there is always a perceptible falling off in the milk production. The latter, however, are decidedly in the minority. Some cases of this nature were found to be due to the fact that the pea-vine silage was partially spoiled, and it is possible that all unfavorable results could be traced to similar conditions.

The following table shows the composition of pea-vine silage from different sources in comparison with corn silage.

Composition of Corn Silage and Pea-Vine Silage.

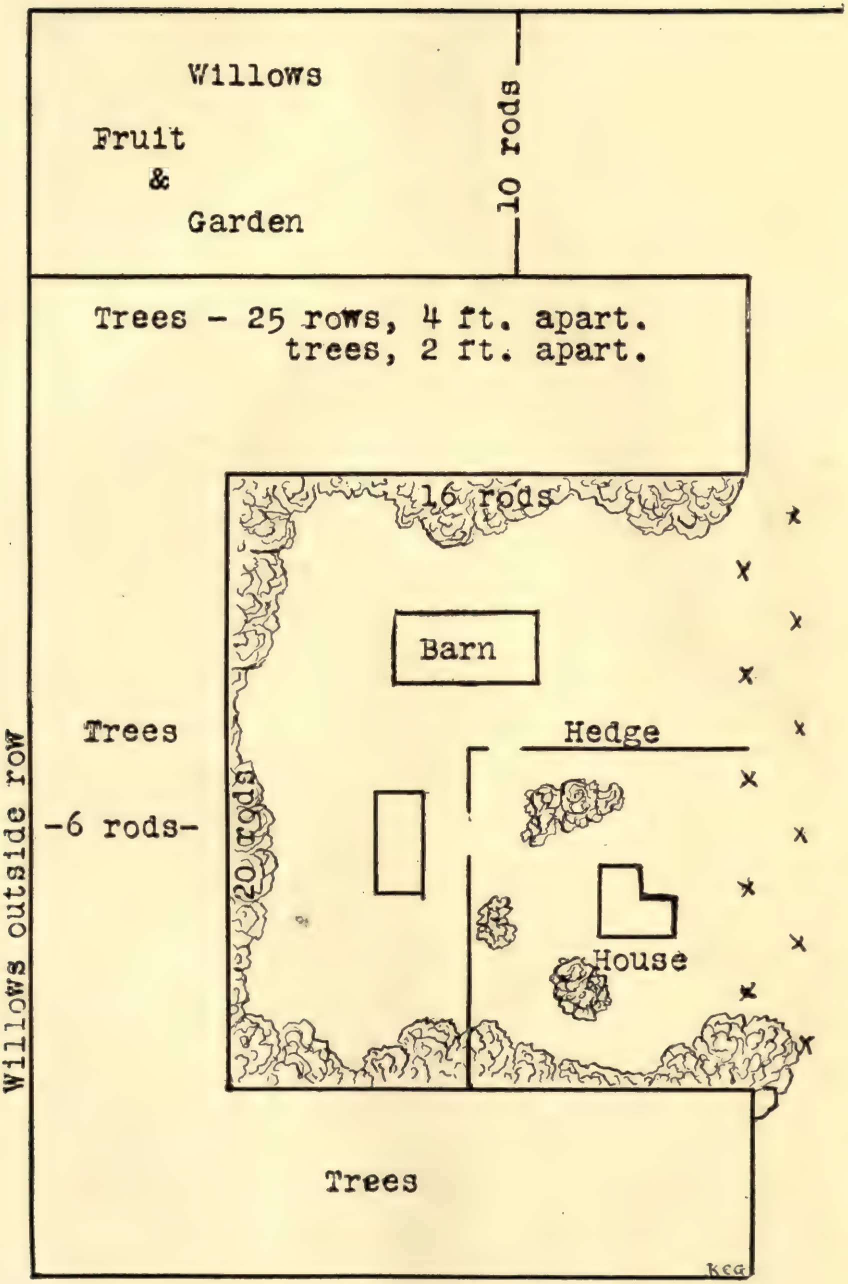
Kind of silage.	Moisture.	Protein.	Fat.	Fiber.	Nitrogen-free extract.	Ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Corn (immature corn) [a]	71.46	2.58	0.97	6.91	16.64	1.44
Corn (mature corn) [a]	64.43	2.58	1.25	8.39	22.04	1.31
Pea vine [a]	67.37	3.59	1.29	8.64	15.35	3.73
Pea vine [b]	72.80	3.65	.86	9.62	10.97	2.10

[a] Annual Report, Wisconsin Agricultural Experiment Station, 1904.
[b] Analysis by Prof. George W. Cavanaugh, Cornell University, Ithaca, N. Y.

It will be seen that pea-vine silage is richer in protein than is corn silage, about the same in fat, but not quite so rich in nitrogen-free extract. Pea-vine silage is especially valuable for late summer feeding when pastures are short and before the corn silage is available.

Pea-Vine Silage for Beef Cattle.—Pea-vine silage has little value as a fat producer, but regardless of this fact it is very highly regarded as a supplementary feed for beef cattle. Quite a number of feeders are using the silage, and almost invariably they claim that their cattle keep in much better condition than where no silage is fed. One New York canner writes that he annually feeds from 250 to 275 steers on the refuse vines from his factory. He begins feeding silage with a little corn meal in the winter. The amount of meal is gradually increased until the animals are on a full ration. They are usually finished off and ready for beef early in June.

Pea-Vine Silage for Sheep.—In many sections of New York and Wisconsin pea-vine silage has come to be very highly regarded as a feed for sheep. In Wisconsin a large number of lambs and wethers that are being fattened for the market are fed on this silage in preference to any other roughage. The common practice is to take the sheep off the pastures about the 1st of November and put them on a ration of silage and corn meal. At first they are given about 10 pounds of silage and from one-half to 1 pound of meal each day. The quantity of silage is gradually decreased and the meal increased, until at the end of thirty or forty days they are



Skeleton Plan for Planting About Farm Premises. Dept. of Agr.

getting 6 pounds of silage and about 2 pounds of corn meal. It generally takes from forty to fifty days to fit sheep for the market on a ration of this kind. The silage is not credited with having any particular value as a fat producer. Its great value lies in the fact that it keeps the animals in good condition, so that they can better assimilate the grain.

It seems to be quite generally conceded that a fine quality of mutton is produced by feeding pea-vine silage that is well kept. In the fall of 1908 a lot of 442 western wethers that had been fed on pea-vine silage and corn in Wisconsin for fifty days topped the Chicago market for heavy export sheep the day they were sold.

Pea-vine silage is an excellent winter feed for breeding ewes. Its laxative qualities keep the bowels in good condition and it produces a large flow of milk. Some sheep breeders who have had quite an extensive experience in feeding this silage prefer it to anything else they can get for their breeding ewes. One large breeder in western New York winters annually from 600 to 700 breeding ewes on pea-vine silage and alfalfa hay, without any grain. His ration is 6½ pounds of silage and 2 pounds of alfalfa hay for each head daily. His ewes come through the winter in fine condition, and their lambs, which come in May, are invariably strong and healthy. He states that he considers this silage superior to all other feed for breeding ewes.

Pea-vine silage has been very successfully used as an exclusive roughage ration for horses, beef cattle, and sheep. When used in this way, the animals are usually fed all they will eat up clean. Horses and cattle will consume from 40 to 80 pounds a day, while sheep will eat from 6 to 12 pounds daily.

Pea-Vine Hay.—The curing of pea vines for hay is a common method of handling them in many sections. This is a popular practice when the farmer is supposed to take home his quota of vines. Farmers living near the factory generally take the freshly thrashed vines home and spread them out to cure on sod land, while those who live some distance away usually spread the vines out to cure on vacant land near the factory.

Pea vine hay is greatly relished by horses, cattle and sheep. Many dairymen prefer it to the best clover hay as a roughage for the cattle. In the winter even hogs will eat quantities of it, and it is excellent for brood sows.

Curing the Vines for Hay.—In curing pea vines for hay they should be taken directly from the viner, spread out on the ground, and left during the day. The next morning, after the sun has dried the dew off, they should be thoroughly stirred up with forks or a tedder. If the weather conditions are favorable, they should be stirred up again after noon and then raked into windrows and put up in cocks. The next day they can be stacked or stored in the barn or shed. When the cured vines are stacked they should be covered with some material which will shed rain, as they readily take up water and are easily spoiled when wet.

In settled weather a good practice is to spread the vines out and let them lie in the sun for a day; then put them up in cocks and let them remain for three or four days. The cocks should be opened and the vines spread out on a bright day so as to dry out the hay in the bottom, which sometimes absorbs considerable moisture, and then hauled to the barn. Some make a practice of sprinkling 5 or 6 pounds of salt over each load as it is placed in the barn, believing that this increases the palatability of the hay.

Pea Vines As a Soiling Crop.—As a green feed or soiling crop the refuse pea vines are probably the equal of any crop grown. Dairymen universally agree that feeding the green vines increases the flow of milk. The use of vines as a soiling crop, however, is confined to a comparatively limited area in the immediate vicinity of a cannery or viner.

Pea Vines As a Fertilizer.—Pea vines have considerable value when used as a fertilizer, especially on soils that are deficient in humus. They are rich in that all-important element of plant food, nitrogen. The following analysis was made by Prof. George W. Cavanaugh, of Cornell University:

Moisture	72.800 per cent.
Nitrogen.........	0.585 per cent, or 11.7 pounds a ton.
Phosphoric acid..	0.111 per cent, or 2.22 pounds a ton.
Potash..........	0.432 per cent, or 8.64 pounds a ton.

—(Bu. Plt. Ind. B. 45.)

Bean vines and pods make an excellent food for sheep, and are very valuable as a fertilizer, as they supply nitrogen to the soil. Many cultivators pick and shell the beans by hand, leaving the vines to be plowed under. Where the bean harvester is used the beans are usually taken to the barn to be threshed.

CONCRETE ON THE FARM.

With the rapid decrease of the timber supply and the resulting increase in the price of lumber there has come a necessary demand for a new building material. Nowhere has this demand been felt more keenly than on the American farm, where lumber has till now been practically the only building material. On account, however, of the farmer's nearness to the timber itself, he has been the last to feel the full effect of the shortage.

A building material has been discovered in concrete that in many instances has proved to be far superior to lumber, brick, or building stones on account of its durability, economy, and safety from fire loss. Moreover, it can very often be used at the most convenient time by the farmer himself with a little assistance.—(F. B. 461.)

The uses of concrete are multifarious. It is used on the farm for cellars, basements, stable floors, walks, driveways, steps and fence posts.

Selection of Materials.—Frequently cement users have made costly mistakes by not informing themselves properly, before starting their work, concerning the correct methods of making good concrete. For this purpose the following materials are necessary:

(1) Cement; (2) sand; (3) gravel or crushed stone; and (4) water.

Cement is therefore only one part of a concrete mixture. A far greater proportion of sand and gravel than cement is required. The quantity of cement to be used and the strength of the concrete depend entirely on the quality and size of the sand and gravel, and it is of the utmost importance that these be of the right kind. With an equal amount of cement a far stronger concrete may be made, if the sand and gravel are of the proper size and correctly proportioned. It is sometimes thought that any kind of soil of a sandy nature, mixed with a small percentage of cement, will make concrete, but this idea is incorrect. As a guide in the selection of the proper materials, especially sand and gravel, the following suggestions should be observed:

Sand.—In the selection of sand the greatest care should be used, and critical attention should be given to its quality, for sand contributes from one-third to one-half of the amount of the materials used in making concrete. Sand may be considered as including all grains and small pebbles that will pass through a wire screen with ¼-inch meshes, while gravel in general is the pebbles and stones retained upon such a screen. The sand should be clean, coarse, and if possible free from loam, clay, and vegetable matter.—(F. B. 461.)

Experiments demonstrate that an exceedingly fine sand requires about seven times the amount of cement required by a coarser sand without increasing the strength of the concrete. If the sand must be washed, the simplest way is to build a loose board platform from 10 to 15 feet long, with one end 12 inches higher than the other. On the lower end and on the sides an edge 2 inches by 6 inches should be nailed to hold the sand. The sand should be spread over the platform in a layer of 3 or 4 inches thick and washed with a ¾-inch garden hose. The washing should be started at the high end and the water allowed to run through the sand and over the 2-inch by 6-inch piece at the bottom. A small quantity of clay or loam does not injure the sand, but any amount over 10 per cent should be washed out.—(F. B. 461.)

Gravel.—The largest part of concrete is the gravel or crushed stone. This should be clean; that is, free from loam, clay, or vegetable matter. The best results are obtained from a mixture of sizes graded from the smallest, which is retained on a ¼-inch screen, to the larger ones that will pass a 1½-inch ring. For heavy foundation and abutment work, larger sized pebbles and stones might be used, while for reinforced concrete work pebbles larger than those passing a 1-inch ring should not be used. If crushed stone and screenings are used, the same care in selecting the sizes must be exercised as in selecting the gravel. In ordering from the crusher plant, the sizes of the stone and screenings should be specified in the order. The crusher dust should always be removed.

Sometimes bank or creek gravel, which will answer the purpose of sand and gravel combined, can be obtained, and it is frequently used on the farm and in small jobs of concrete work just as it comes from the pit or creek. Occasionally this gravel contains nearly the right portions of sand and gravel, but in the majority of sand pits and gravel banks there is a great variation in the sizes of the grains and pebbles or gravel, and in the quantities of each. This is due to the fact that all the deposits are formed in seams or pockets that make it impossible to secure anything like uniformity. Therefore, to get the best and cheapest concrete, it is advisable to screen the sand and gravel and to remix them in the correct proportions.—(F. B. 461.)

Water.—The water used for concrete should be clean and free from strong acids and alkalis.

Care of Cement.—In storing cement care must be exercised to insure its being kept dry. When no house or shed is available for the purpose, a rough platform may be erected clear of the ground, on which the cement may be placed and so covered as to exclude water. When properly protected, it often improves with age. Cement is shipped in barrels or bags.—(F. B. 235, 461.)

Manufacture of Concrete.—The strength and durability of the concrete depends, (1) on the care in selecting the materials to be used, (2) on exercising equal care in proportioning the material, and (3) on the time and skill displayed in the mixing and setting of the concrete.

Cement mortar is an intimate mixture of cement and sand mixed with sufficient water to produce a plastic mass. The amount of water will vary according to the proportion and condition of the sand, and had best be determined independently in each case. Sand is used both for the sake of economy and to avoid cracks due to shrinkage of cement in setting. Where great strength is required, there should be at least sufficient cement to fill the voids or air spaces in the sand, and a light excess is preferable in order to compensate for any uneven distribution in the mixing. Common proportions for Portland cement mortar are 3 parts sand to 1 of cement, and for natural cement mortar, 2 parts sand to 1 of cement.

A lean mortar is one having only a small proportion of cement, while a rich mixture is one with a large proportion of cement. Neat cement is pure cement, or that with no admixture of sand. The term aggregate is used to designate the coarse materials entering into concrete—usually gravel or crushed rock. The proportion in which the three elements enter into the mixture is usually expressed by three figures separated by dashes—as, for instance, 1-3-5—meaning 1 part cement, 3 parts sand, and 5 parts aggregate.

In the great majority of cases cement mortar is subjected only to compression, and for this reason it would seem natural, in testing it, to determine its compressive strength. The tensile strength of cement mortar, however, is usually determined, and from this its resistance to compression may be assumed to be from eight to twelve times greater. A direct determination of the compressive strength is a less simple operation, for which reason the tensile test is in most cases accepted as indicating the strength of the cement.—(F. B. 235, 461.)

Proportions of Mixture.—For an accurate determination of the best and most economical proportions where maximum strength is required, it is well to proceed in the following way: First, proportion the cement and sand so that the cement paste will be 10 per cent in excess of the voids in sand; next, determine the voids in the aggregate and allow sufficient mortar to fill all voids, with an excess of 10 per cent.

The proportions are always measured by volume. A 1:2:4 mixture means one part of cement, twice as much sand, and four times as much stone or gravel, so that the whole mixture consists of seven parts. A 1:2½:5 mixture means one part of cement, two and one-half times as much sand, and five times as much stone or gravel, so that the whole mixture consists of eight and one-half parts. It should be noticed that the dimensions given for the measuring boxes for sand and stone or gravel are inside measurements. These boxes are made with straight sides of any kind of rough boards and have no top or bottom.

Variations in Mixture.—If the sand is very fine, the cement should be increased from 10 to 15 per cent. When the mixture does not have a uniform color, but looks streaky, it has not been fully mixed. If the mixture does not work well, and the sand and cement do not fill the voids in the stone, the percentage of stone should be reduced slightly, but the concrete should first be properly mixed. Concrete that is poorly mixed may present features that are entirely eliminated by turning it over once or twice more.

Determination of Quantities.—The number of cubic feet of concrete that will be required for the work in question should first be calculated. By multiplying this number by the number under the proper column in the following table the amount of cement, sand, and stone or gravel can be found.

Quantities of Materials in 1 Cubic Foot of Concrete.

Mixture of concrete.	Cement (by barrels).	Sand (by cubic yards).	Stone or gravel (by cubic yards).
1:2:4	0.058	0.0163	0.0326
1:2½:5	.048	.0176	.0352

—(F. B. 461.)

Equipment for Mixing Concrete.—When the proper materials have been selected, the next step is to mix them properly and with dispatch. On large jobs it is more economical to mix concrete by machine, but for small jobs, using even as much as several hundred cubic yards of concrete, it is much cheaper and more expedient to mix by hand. This is, of course, especially true when only two or three men are available and the work is often interrupted. There are many ways of mixing by hand, all of which have the same good results. The way herein described is believed to be the one best calculated to obtain good results with a minimum of labor. In this description a 2-bag batch of 1:2:4 concrete is taken as the basis of the calculation.

The Concrete Board.—A concrete board for two men should be 9 feet by 10 feet. It should be made of 1-inch boards, 10 feet long, surfaced on one side, and should be held together by five 2-inch by 4-inch by 9-foot cleats. If tongue and groove roofers 1 inch by 6 inches can be obtained, fairly free from knots, they serve very well. The boards are surfaced in order to make the shoveling easy. They are so laid as to permit the shoveling to be done in the direction in which the cracks run, so that the shovel points will not catch in the cracks. The boards must be nailed close together so that no cement grout may run through them during the mixing. Knot holes may be closed by nailing a strip across them on the underside of the board. It is a good precaution against losing cement grout to nail a piece of wood 2 by 2 inches or 2 by 4 inches around the outer edge of the board.

The concrete board is the manufacturing plant, and the advantages of its location should be carefully considered. Generally it is best placed as close as possible to the forms in which the concrete is to be deposited, but local conditions must govern this point. A place should be selected which affords plenty of room and is near the storage piles of sand and stone or pebbles. The concrete board should be raised on blocks so as to be level, in order that the cement grout may not run off on one side and that the board may not sag in the middle under the weight of the concrete.

Runs.—The boards for the wheelbarrow runs should be carefully selected. The run should be well built, smooth, and at least 20 inches wide, if much above the ground. It is surprising how this one feature will lighten and quicken the work.—(F. B. 461.)

Method of Mixing.—When the mixing board has been arranged and the "runs" are made, the concrete plant is ready. The sand should be spread over the board in a layer 3 or 4 inches thick. Two bags of cement should then be spread as evenly as possible over the sand. Two men should then start mixing the sand and cement in such a way that each man may turn over the half on his side of a line dividing the board in half. Starting at his feet and shoveling away from himself, each man should take a full shovel load, and in turning the shovel, he should not simply dump off the sand and cement, but should shake the materials off the end and sides of the shovel, so that they may be mixed as they fall. This is a means of great assistance in mixing these materials, and in this way the material is shoveled from one side of the board to the other.

The sand and cement should now be well mixed and ready for the stone and water. After the last turning, the sand and cement should be spread out carefully, and the gravel or stone measuring box should then be placed beside them and filled from the gravel pile. The box should now be lifted off, the gravel shoveled on top of the sand and cement, and spread as evenly as possible. About three-fourths of the required amount of water should be added with a bucket, and the water should be dashed over the gravel on top of the pile as evenly as possible. Care should be taken not to let too much water get near the edges of the pile, because it may wash away some of the cement as it flows off. This caution, however, does not apply to a properly constructed mixing board, where water can not flow away. Starting in the same way as with the sand and cement, the materials should be turned over in much the same manner, except that, instead of shaking them off the end of the shovel, the whole shovel load should be dumped and dragged back toward the mixer with the square point of the shovel. The wet gravel picks up the sand and cement, as it rolls over when dragged back by the shovel, and the materials are thus thoroughly mixed. Water should be added to the dry spots as the mixing goes on until all that is required has been used. The mass should be turned back again, as was done with the sand and cement. With experienced laborers, the concrete would be well mixed after three such turnings; but if it shows streaky or dry spots, it must be turned again. After the final turning, it should be shoveled into a compact pile. The concrete is now ready for placing.—(F. B. 235, 461.)

Placing the Concrete.—After the concrete is properly mixed, it should be placed at once. Concrete may be handled and placed in any way best suited to the nature of the work, provided that the materials do not separate in placing. Concrete may be placed properly by shoveling off the concrete board directly into the work; by shoveling into wheel-barrows, wheeling to the proper place, and dumping; by shoveling down an inclined chute; or by shoveling into buckets and hoisting into place. Concrete should be deposited in layers about 6 inches thick, unless otherwise specified.

Protection of Concrete After Placing.—New concrete should not be exposed to the sun until after it has been allowed to harden for five or six days. Each day during that period the concrete should be wet down by sprinkling water on it both in the morning and afternoon. This is done so that the concrete on the outside will not dry out much faster than the concrete in the center of the mass, and it should be carried out carefully, especially during the hot summer months. Old canvas, sheeting, burlap, etc., placed so as to hang an inch or so away from the face of the concrete, serve very well as a protection when wet. Often the concrete forms can be left in place a week or ten days, thus protecting the concrete during the setting-up period, and the above precautions are then unnecessary.

Forms for Concrete.—Concrete is a plastic material and, before hardening, takes the form of anything against which or in which it is placed. Naturally, the building of the form is a most important item in the success of the work. These forms hold the concrete in place, support it until it has hardened, and give it its shape as well as its original surface finish.

Almost any material which will hold the concrete in place will serve as a form. Concrete foundations for farm buildings require shallow trenches, and, up to the ground line, usually the earth walls are firm enough to act as a form.

Forms should be well planned, so that there may be no difficult measurements to understand. As few pieces of lumber should be used for the work as possible, and these should be fastened together by as few nails as will serve the purpose; otherwise it will be difficult to take the forms apart without splitting them.

Forms must be strong enough to hold the weight of the concrete without bulging out of shape. When they bulge, cracks may open between the planks, and the water in the concrete, with some cement and sand, may leak out. This weakens the concrete and causes hollows in the surface, which have a bad appearance after the forms are removed.

Forms which lose their shape after being used once can hardly be used a second time. A part of the erection cost of forms is saved if the forms are built in as large sections as it is convenient to handle. This saving applies to their removal as well as their erection. Consequently the lightest forms possible with the largest surface area are the most economical.—(F. B. 461.)

Notes.—A dry mixture, from which water can be brought to the surface only by vigorous tamping, is probably the strongest, but for the sake of economy, and to insure a dense concrete well filling the molds, a moderately soft mixture is recommended for ordinary purposes. Where the pieces to be molded are thin, and where small reinforcing metal rods are placed close together or near the surface, a rather wet mixture may be necessary to insure the molds being well filled.

In the manufacture of such articles as pipe, fence posts, and hollow blocks, a rather large proportion of quick-setting cement is sometimes used, the object being to reduce the weight and consequent freight charges by means of a strong mixture, as well as to make the concrete impervious to water. The use of a quick-setting cement permits the molds to be removed sooner than would be possible with a slow-setting cement, thus reducing the number of molds necessary for a given output. Quick-setting cements are not recommended for such purposes, however, as they are usually inferior to those which set slowly.

In coloring cement work the best results are obtained by the use of mineral pigments. The coloring matter, in proportions depending upon the desired shade, should be thoroughly mixed with the dry cement before making the mortar. By preparing small specimens of the mortar and noting the color after drying, the proper proportions may be determined. For gray or black, use lampblack. For yellow or buff, use yellow ocher. For brown, use umber. For red, use venetian red. For blue, use ultramarine.

The time required for concrete to set depends upon the character of the cement, upon the amount and temperature of the water used in mixing, and upon the temperature of the air. Concrete mixed dry sets more quickly than if mixed wet, and the time required for setting decreases as the temperature of the water rises. Warm air also hastens the setting.

Although it is advisable under ordinary circumstances to discontinue cement work in freezing weather, Portland cement may be used without serious difficulty by taking a few simple precautions. As little water as possible should be used in mixing, to hasten the setting of the cement. To prevent freezing, hot water is frequently used in mixing mortar or concrete, and with the same object in view salt is added in amounts depending upon the degree of cold. A common practice is to add 1 pound of salt to 18 gallons of water, with the addition of 1 ounce of salt for each degree below 32° F. Either of the above methods will give good results, but it should be remembered that the addition of salt often produces efflorescence. It seems to be a fairly well established fact that concrete deposited in freezing weather will ultimately develop full strength, showing no injury due to the low temperature.—(F. B. 235.)

LEGAL WEIGHTS PER BUSHEL OF SEEDS.

While the selling of seeds by the measured bushel has largely disappeared in the trade, the weight per bushel still has an important value in determining grade, especially in grass seeds, which vary greatly in quality. Redtop seed, weighing 10 pounds per bushel, is composed largely of chaff and contains a very small percentage of good seed, while fancy seed, containing from 85 to 95 per cent of pure seed, weighs from 35 to 40 pounds per bushel. Similar variations in weight exist in connection with the handling of other common grass seeds, such as bluegrass, orchard grass, brome-grass, ryegrass, and the fescues. The weights per bushel of grains do not vary as much as do those of grass seeds, but nevertheless the weight per bushel is an important factor to be considered in grading.

In numerous instances the customary weights per bushel of seeds used by the trade are not the same as the legal weights. In many of the principal cities the Boards of Trade and the Chambers of Commerce use a system of weights that do not accord with those fixed by statute.—(Bu. Plt. Ind. B. 51.)

THE USE OF PAINT ON THE FARM.

Any man can do an average job of painting, and can, thereby, improve the appearance of his place and add greatly to the durability of all articles painted. The necessary equipment is not expensive, and with proper care will last a long time.

Brushes and Other Implements.—The only absolutely necessary implements are brushes. Probably the most generally useful brush is a round one with bristles about 6 inches long. Oval brushes from 2 to 2½ inches wide are also very good for general use, and a great deal of painting is done with 4 or 5 inch flat brushes. The advantage of a flat brush is that a greater amount of surface is covered at a stroke, with the disadvantage that the paint can not be as thoroughly rubbed in. On the whole, therefore, it is best to use a round brush.

Dusting brushes made of stiff bristles are useful for cleaning the surface before painting. For cleaning rusted metal surfaces, steel-wire brushes (2 or 3 inches wide and 6 inches long with wires about 3 inches long) are frequently necessary.

If ready-mixed paints are bought the cans may serve as buckets, but if the paint is mixed from the paste a strong tin bucket large enough to allow for stirring the paint will be necessary. Scraping knives and putty knives are necessary tools for the painter, and it is well to have one or two of each, but a very good scraper can be improvised for a piece of sheet iron, and an old kitchen knife may be ground to a square end and converted into a very serviceable putty knife. A paint strainer is useful, but two thicknesses of cheesecloth tied over the top of a bucket answers practically as well. Paint should be strained before using it.

Care of Brushes.—Brushes for applying oil paints must be well cleaned after using, though for keeping overnight it is generally sufficient to wrap them in several thicknesses of paper. Some painters keep their brushes overnight by putting them in water. If, however, the brush is not to be used for several days, the paint should be washed out of it. Turpentine is one of the most satisfactory materials for washing a brush; a brush can generally be washed as well with kerosene, which is much cheaper. After washing off the paint with kerosene the brush should be rinsed with gasoline or benzine, then thoroughly shaken and well washed with soap and warm water.

Brushes used with whitewash or calcimine should simply be washed and not put in the same liquids in which the brushes used for oil paints are kept. If a brush has been used for shellac varnish it should be kept in alcohol or in the varnish itself. In general a varnish brush may be kept in the varnish in which it is used. Water paints such as whitewash and calcimine dry in the ordinary sense; that is, by evaporation of the liquid, which in the case of the two paints mentioned is water.

The formation of a varnish-like film by the so-called drying of linseed oil is an exceedingly important operation in the drying of oil paints. Certain substances, compounds of lead and manganese, if dissolved in the oil, hasten drying. Boiled oil which contains compounds of lead or manganese, or both, will dry more rapidly than raw linseed oil. Instead of using boiled oil, however, the drying of the oil in paints is generally hastened by the addition of liquids known as driers. These liquids are composed of compounds of lead and manganese generally thinned with either turpentine or benzine, and are known as japan or japan driers. While the use of a drier is necessary in a great many paints, the amount used should be small. There is another objection to the use of a large amount of drier, and that is that the film produced is not so durable as one produced by raw linseed oil alone or by the use of a raw oil containing the proper amount of drier. There are a number of other oils which have the property of drying like linseed oil, but none of them is the equal of linseed oil for a paint vehicle.

Some pigments, however, have the property of hastening the drying of linseed oil, and any other drier. The varnish-like film left by linseed oil is for practical purposes insoluble in water. It is not, however, impervious to water. But, if an oil paint is employed—that is, a mixture of pigment and linseed oil—it will be found that water does not penetrate through the film so rapidly as it does through the linseed-oil film alone. Also the paint film is more resistant to mechanical abrasion. While there is some difference of opinion among experts as to the amount of pigment which should be used in a paint, it is generally considered that the greater the amount of pigment the more resistant the paint film is, provided all the particles of pigment are thoroughly covered with the oil. It would appear, therefore, that a film of oil, while it may seem to be homogeneous even if examined under a high-power microscope, is really porous, and by mixture of the oil with the pigment the pores are more or less completely filled, thus making a more impervious film. In addition to the linseed oil and drier, paints frequently contain volatile substances, such as turpentine and benzine. The addition of these is largely for the purpose of thinning the paint to a better working consistency, so that it can be spread in thin layers more easily. These volatile substances evaporate almost completely and do not remain behind in the dried film. The only substance remaining which binds the solid particles of the pigment together is the oil.

Preparation of Surfaces for Painting.—All surfaces should be clean and as dry as possible before the application of an oil paint. Much new wood is very difficult to paint. The resins in such woods as yellow pine and spruce tend to destroy any paint that is laid over them. When possible, it is well to allow a new house to stand unpainted for at least six months or even a year after the woodwork has been completed. By this exposure to the weather the resins are brought to the surface and are either washed away or hardened, and the resulting wood surface is in much better condition for painting than is a new structure. Painters adopt several methods of treating new wood; probably the one most universally used is to coat all knots and other places where resin appears with shellac varnish, a solution of gum shellac in alcohol. Another plan is to mix with the priming coat of paint a small amount of benzol (coal-tar naphtha), which is claimed by some excellent authorities on painting to dissolve the surface layer of resins and allow the paint pigment to penetrate into the fibers of the wood, preventing the final forcing of the resins to the surface. After applying the priming coat, all nail holes and cracks should be well filled with putty pressed in hard. Filling in with putty should not be attempted before the priming coat is applied, as it is not likely to stick as well. In painting iron surfaces all rust and grease should be carefully removed, scraping the surface down to bright metal with wire brushes or sandpaper and finally dusting off all adhering particles. Painting should be done in warm, dry weather. It is much better to select the summer time for painting than the winter.

Painting Exterior Woodwork.—All wood is more or less porous, and the natural result of applying a substance like paint to such a material is that the liquid portion sinks into the wood and leaves a large portion of the solid material on the surface. Also different parts of the wood will differ in porosity, and there will tend to be different amounts of paint left on different portions of the surface. In order to do a good job of painting it is practically always necessary to apply several coats to new wood. The first or priming coat is made thinner than the others, the amount of thinning depending upon the porosity of the wood. For ordinary pine, a paint of proper spreading consistency, when mixed with an equal volume of raw linseed oil, furnishes a good material for priming. With very porous wood, more oil may be added. The priming coat should be applied with as much care as any other and should be thoroughly brushed into the wood, the brushing being carefully done so that the paint is evenly distributed, with no tendency to run. The paint for priming should consist of the pigment, linseed oil, and a minimum amount of drier, with no turpentine or benzine; and after applying it at least a week and preferably longer should elapse before putting on the second coat.

Three coats at least are generally necessary to make a good piece of work. The effect of the priming coat, if properly applied, is to fill the pores of the wood and furnish a foundation on which to apply subsequent coats. Owing to the difference in porosity of different parts of the surface, it is almost impossible to completely fill with one priming coat, and an attempt to get a good effect by applying the finishing coat immediately on top of the priming generally results in failure. A second coat will not penetrate to any very great extent into the wood. It should not, however, dry with a gloss, because a glossy surface does not furnish a good foundation for the next coat. In order to prevent the gloss, add turpentine to the paint for the second coat; the amount used, however, should be small—to each gallon of paint about a half pint of turpentine in hot weather, or a pint in cold weather, is sufficient. The second coat, which of course should have been evenly spread and well rubbed in with the brush, should be allowed to dry somewhat longer than the priming coat. The third, or finishing coat, should be one which will dry with a gloss, and for this purpose there should be no turpentine or thinner added to the paint at all.

Interior Painting.—The main point in selecting a paint for this work is to choose one which will cover well the article to be painted and which contains colors that are permanent. The actual protective coating may be assumed to last as long as there is any necessity for it. Very light tints or very brilliant colors are likely to fade, and white paints containing a large amount of oil tend to turn yellow in dark rooms. The pigment lithopone, which is not suitable for outside work, can be used with satisfaction for interior painting. Calcimines, the so-called cold-water paints, in which no oil or expensive lead or zinc pigments are used, and which are, therefore, very much cheaper than oil paints, last very well on the inside.

For interior work the same directions apply as to outside painting, but it is not so important to have the final coating contain such a large amount of oil as to give a glossy finish. A dull finish is preferred by many people, and since this paint is not to be exposed to severe weather conditions, a larger amount of thinner may be used than for outside work. Also, paint for inside work should dry faster than one for the outside, and a somewhat larger amount of japan drier is generally used.

Painting of Metal.—Tin or other metal roofing, also galvanized iron such as gutters and rain spouts, are very difficult to paint, as often the paint does not stick well. This is probably due to a very thin film of grease left on such material from the process of manufacture, and before attempting to paint a tin roof it is best to scrub it perfectly clean with soap and water or with cloths moistened with benzine, and then thoroughly dry before applying the paint. Galvanized iron may be treated in the same way, but it is much better to let this material stand for some time exposed to the weather before painting. The metal portions of machinery are generally cast iron or steel; wrought iron is rarely used. There is perhaps nothing that actually needs paint for protection as much as the steel and iron portions of machinery. Before painting such material the greatest care should be taken to get the surface perfectly clean. Do not apply paint over rust, but clean thoroughly down to the bare metal with scrapers or wire brushes, and finally with dry scrubbing brushes. It is a mistake to spare labor in preparing a metal surface for paint. All oil and grease should be scrupulously removed, and the metal surface should be absolutely clean and dry before painting. The paint should be well brushed on, carefully filling all cracks.

Two or three coats of any good paint may be used. The paint which is generally supposed to protect iron from rusting better than any other is red lead. The addition of a small amount of lampblack improves the color and the working quality of red-lead paint. A paint made of basic chromate of lead (so-called scarlet lead chromate, or American vermilion) is even better than red lead as a material for protecting iron.

Composition of Paints.—A very good rule to follow in purchasing mixed paints is to buy nothing which does not bear the name of the manufacturer. If the manufacturer's name does not appear on the label this is very good presumptive evidence that he is not particularly proud of his product. Many state laws require that the composition of paints should also be stated on the labels, and a large number of the best manufacturers do this whether their products are sold in a state requiring such labeling or not.

The most expensive paints are generally white paints or very light tints. The reason for this is that there are comparatively few white pigments which have covering power, i. e., the property of hiding the surface of the material painted. All of the cheaper white pigments are more or less transparent in oil and are, therefore, deficient in covering power. White lead, zinc white, sublimed white lead, zinc lead, and lithopone are practically the only white pigments which have good covering power in oil. These pigments are all rather expensive, and as they are heavy it takes quite a large amount to make a paint.

Of the dark shades, there are a number of cheaper pigments which have very good covering power. It may be quite safely stated that for a white paint that really covers, some one or more of the white pigments just enumerated must be used. For a dark brown, however, a good covering can be obtained with an iron oxid pigment, which is very much cheaper. Therefore, for such paints there is no reason for using an expensive lead or zinc pigment.

Tinted paints, at least those of light tint, consist practically of white paint with the addition of a small amount of coloring matter. The coloring materials used in tinting are not uniform. In general, gray tints are made from white paints by the addition of a black pigment, such as lampblack or bone black, and sometimes a small amount of red or blue is used also. The total amount of coloring matter employed varies, but rarely amounts to as much as 5 per cent. Buff may be made by the addition of mixtures of ocher and umber; brown, by the addition of mixtures of black, red, and sometimes yellow. Yellow and cream may be made by the addition of ocher or chrome yellow; frequently for this purpose golden ocher is used, which is ordinary ocher brightened by the addition of a small amount of chrome yellow. Blue tints may be made by the addition of small amounts of Prussian blue. This is a powerful tinting pigment, and it is seldom that more than 1 per cent is required. With the white paints which contain no lead, ultramarine blue may be used instead of Prussian blue; but ultramarine blue should not be used with lead paints. Besides the tinted white paints, bright colors are sometimes desired, especially green, for blinds, and reds for the trimmings of houses or for machinery. These paints seldom contain any large amount of the expensive lead and zinc white pigments, but consist of comparatively small quantities of coloring matter and large amounts of the cheap white pigments. For black paints there is practically only one coloring substance, namely, carbon, which, however, occurs commercially in a number of forms. The color of so-called drop or ivory black is carbon, obtained from charred bone; lampblack is carbon in the form of soot. The latter, although very pure, does not make a satisfactory black alone, the heavier forms of carbon, such as bone black or even ground charcoal, producing a better black.

For dark shades of brown or red there is probably nothing which is as cheap as the oxid of iron pigments. These vary very much in shade, giving both browns and dull reds. A pigment that gives a very satisfactory reddish brown and contains about 40 per cent of iron oxid makes a satisfactory paint containing approximately 56 per cent pigment and 44 per cent vehicle, the vehicle being very much the same as that used in a first-class white paint.

Whitewash.—Whitewash is the cheapest of all paints, and for certain purposes it is the best. Lime, which is the basis of whitewash, makes a very sanitary coating, and is probably to be preferred for cellars and the interior of stables and other outbuildings. Ordinary whitewash is made by slaking about 10 pounds of quicklime with 2 gallons of water. The lime is placed in a pail and the water poured over it, after which the pail is covered with an old piece of carpet or cloth and allowed to stand for about an hour. With an insufficient amount of water, the lime is "scorched" and not all converted into hydrate; on the other hand, too much water retards the slaking by lowering the heat. Scorched lime is generally lumpy and transparent, hence the use of the proper amount of water for slaking and an after addition of water to bring it to a brush consistency.

Weatherproof Whitewash (Exteriors) For Buildings, Fences, Etc.—(1) Sixty-two pounds (1 bushel) quicklime, slake with 12 gallons of hot water. (2) Two pounds common table salt, 1 pound sulphate of zinc, dissolved in 2 gallons of boiling water. (3) Two gallons skimmed milk. Pour (2) into (1), then add the milk (3) and mix thoroughly. Alum added to a lime whitewash prevents it from rubbing off. An ounce to the gallon is sufficient.—(F. B. 474.)

Calcimine.—Cold water paints or calcimine have as their basis whiting or carbonate of lime instead of caustic lime, as in whitewash. This material itself does not adhere, and it is necessary to use a binder of some kind, generally glue or casein. Scott also gives the following directions for making calcimine: Ordinary white stock (calcimine)—(1) Sixteen pounds dry Paris white (whiting) mixed until free of lumps, with 1 gallon boiling water. (2) One-half pound white sizing glue; soak 4 hours in one-eighth gallon cold water. Dissolve on a water-bath (gluepot) and pour into (1). The above recipe makes about 2 gallons of stock, weighing 12¾ pounds per gallon. It is of proper brush consistency and may be used at once, but is better after standing half an hour. Any tint may be given the white stock by stirring the desired dry color in a little water and adding sufficient liquid color to the base.—(F. B. 474.)

LAWNS.

Beautifying the Farm Grounds.—The appropriate use of trees, shrubs, vines and herbaceous plants in the adornment of city, village, suburban or country home grounds gives a charm and beauty which are interesting and pleasing to the passer-by as well as to the occupant of the home. Plants are a means of expressing restfulness and beauty. Their gradually changing aspect with the succession of the seasons heightens their pleasing effect and relieves monotony. —(L. C. C., Hort. Dept. Ag.)

Trees and shrubs around a home not only add beauty to the surroundings, but if the trees are rightly selected they are great sanitary agents, taking from the atmosphere the malaria that otherwise would prove injurious to the health of those occupying the homes. It is all too common in America for farmers to educate their sons and daughters, sending them away from home for that purpose, and then to neglect to make home pleasant and delightful to look at when they return. Out in the world they see homes with well-shaded and beautiful surroundings and a taste for the beautiful is thus inculcated or acquired, and when they return to the farm with its house set out in the blazing sun, without a tree or shrub, and possibly without a flower except an old, antiquated rose bush or a deserted looking hollyhock, and a total absence of the beautiful, they become dissatisfied, and as soon as possible they leave the farm for the city where their taste for the beautiful can be gratified.

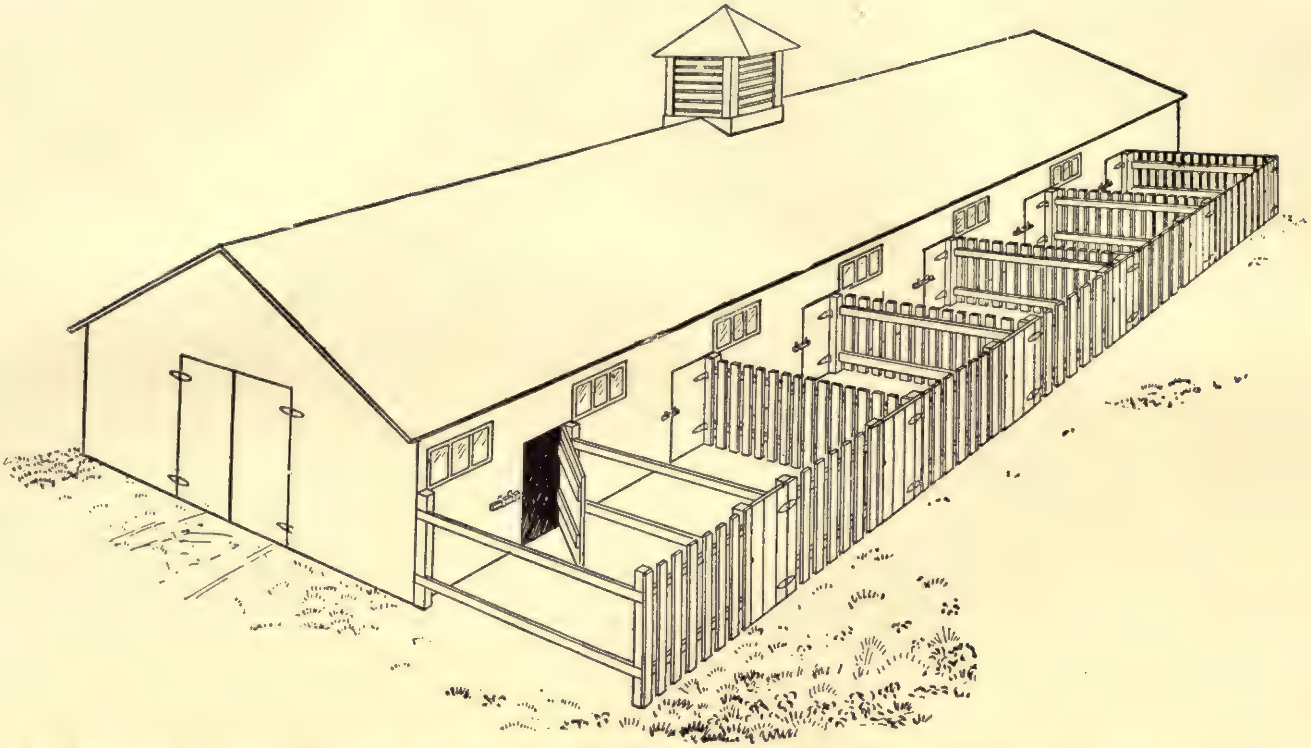
There is no reason why the home surroundings of the farmer should not be as tasteful and beautiful as that of the city or suburban resident; have its well-set lawn, its well-selected groups of shrubs, and its well-trimmed shade trees. To have all this requires but little labor and expense, and the interest on the investment of labor and money will return a hundred fold in the enjoyment of the farmer himself, to say nothing of the return in making his children contented and in love with life on the farm.

In the artificial adornment of grounds by means of plants, nature is our best instructor. From here we learn the use of grass, flowers, vines, shrubs and trees, and how to combine them to the best advantage. By growing together for ages, the various classes and species of plants have developed forms, habits and requirements which enable them not only to live and thrive in harmony, but actually assist one another.—(L. C. C.)

The proper adornment of the lawn must depend to some extent on its extent and the contour of the ground, but every farm house has ground enough around it to give opportunity for display of taste in the selection of the grass for the sward, the plants, and in their arrangement. While every lawn should have a proper number of trees for the grateful shade they will give and for their general effect in the plan of adornment, the sward is the first and greatest consideration.

The Soil.—To grow grass luxuriantly enough to make a beautiful lawn the right soil is of importance. This cannot always be had, but it may be approximated. The ideal soil for grasses for lawn purposes is one which is moderately moist and contains a liberal percentage of clay. It should be a soil that is inclined to become heavy and compact. In many localities it will be impossible to get the ideal soil, but effort should be made to approach the ideal as near as possible, by careful preparation. This can be done in several ways. The best and most effective way is by the liberal use of fertilizers, bearing in mind that the soil cannot be made too rich.

Where a pure sand or a light sandy soil is found it should be given a top dressing of clay, two or more inches in depth, and this should be thoroughly incorporated with the native sand. It may require two or three years to make a soil for the grass, hence too much haste should not be indulged in. On the sandy soil after its top dressing of clay has been thoroughly incorporated it is well to grow one or two green crops which give an abundance of vegetable matter, such as cowpeas, red clover or Canada peas. These crops should be allowed to remain until their maximum growth is attained and then should be plowed under. This will make the soil more



Hog House for Northern Latitudes, Side Elevation, Showing Arrangement of Outside Feeding Pens. B. A. I. 20th Rpt.

retentive of moisture and less liable to let the sward made on it be killed in times of drought.

It is hardly possible to make the soil too rich. In fact, it ought to be as rich as it can be made, as the lawn is to be a permanent feature and not to be renewed year after year. Therefore fertilizers should be liberally used to assist nature. Thoroughly rotted and composted stable manure is the best, but it should be as free from weed seeds as possible. Experts recommend that the land should receive an application of about 1,000 pounds of lime to the acre, and then at the time of preparing the seed bed should be added from 500 to 1,000 pounds of fine-ground bone, together with 300 to 500 pounds of a high grade fertilizer. It should be remembered that in the beginning nothing should be spared to lay a good foundation for the sward that is to be made.

The seed bed should not be more than an inch deep, but deep cultivation and thorough preparation should be made in order that the long, lateral feeding roots of the grass may find an abundance of food. The soil, therefore, should be enriched to a depth of eight or ten inches. The seed bed should be frequently and thoroughly stirred, so as to grind the soil particles together, in order to release the plant food.—(Dept. Agr. B. 248; O. Ex. S. B. 106; Ill. U. B. 138; B. of S. B. 75.)

About Grasses.—After the ground has been thoroughly prepared comes the selection of the grasses. All grasses are not adapted to lawn-making, and grasses that will make a good lawn in one section may not be adapted to another where different climatic conditions prevail. In determining on the grass climatic conditions and soil should be taken into consideration. Only such grasses as are capable of making a close turf are ideal for lawns. Such grasses as are able to withstand drought or severe atmospheric changes should be selected. The list of suitable lawn grasses is a very limited one. In the localities where ideal soil and climatic conditions are not present a mixture of grasses is recommended. Where the proper condition of soil and climate obtain a better and more satisfactory lawn can be made by using a single variety than with a mixture.

In the North Atlantic coast States and in those of the Middle West, and as far south as Northern Georgia, Kentucky bluegrass is best adapted for lawns. Bluegrass thrives best in a comparatively retentive soil, where rain is abundant. Upon soils of a lighter character, and in localities where precipitation is greater, such grasses as red top, Rhode Island bent grass, creeping bent grass and white clover are more to be relied upon. These grasses all have the same ability to make a compact and deep sward as does bluegrass. In the States south of the Potomac white clover forms an important part of seed mixtures for lawn use. A good mixture is equal weights of Kentucky bluegrass and red top, with a pound of white clover to the bushel of the mixture. Bluegrass and red top mature at different seasons, the red top reaching maturity some weeks later than the bluegrass, thus keeping up a better succession through the season.

The clover is useful in thickening the sod and by its ability to gather nitrogen it assists the growth of the grasses with which it is sown.

South of the Potomac in the Atlantic coast States Bermuda grass does very well for lawn purposes. In certain sections west of the Mississippi River Buffalo grass would make an admirable lawn. It withstands the drought and is able to establish and maintain itself under adverse climatic conditions. In selecting the grass to be used climatic conditions should largely govern. In mixtures care should be exercised to select grasses of like habits of growth and coloring. Otherwise the lawn is apt tc have a spotted appearance.—(F. B. 248; Dept. Ill. U. 138; O. Ex. Sta. 106; B. of S. B. 75.)

Selecting the Seed.—Pure seed is the very foundation of securing a clean and perfect lawn. Without that the very best preparation will fall short. In securing a good stand of grass pure seed of high germination is of the greatest importance. One of the chief charms of a lawn is to have an even stand of grass of uniform color. Where it is possible to obtain it specially selected seed should be used. The purity of the seed can, in a measure, be determined by its weight. The ordinary grade of bluegrass seed used for commercial purposes averages only about twelve pounds to the bushel, while the select seed fit for lawn use weighs about twenty-two pounds to the bushel.

In making a good lawn it is also important that plenty of seed be used. It is better to use an excessive amount of seed rather than to seed sparingly. A thick stand of healthy growing grass gives little opportunity for the growth of weeds, while a thin stand gives the weeds an abundant opportunity. Bluegrass and the bent grasses should be sown at the ratio of two or three bushels to the acre. If used alone bluegrass should not be used at less than two bushels to the acre. A peck of white clover to the acre is sufficient if used in combination with bluegrass. In some soils white clover is an important factor, as it germinates quickly and covers the ground. It is also able to re-establish itself very quickly after periods of severe drought. As the other grasses become more marked in the farming of the turf the clover will disappear.

Manner and Time of Sowing.—After the seed has been selected the manner and time of sowing becomes important. Since grass seed is very small care should be taken to bring it in close contact with the ground. It is therefore desirable to sow the seed immediately before a shower. In lawn planting, as in many other things, a difference of opinion prevails as to the best time for sowing the seed, some advocating spring sowing and others favoring the fall. If in the fall the seeding should be done at the time of the fall rains. It is never advisable to sow a lawn in a dry season. In localities where snow falls but slightly in the winter fall planting should not be resorted to.

Spring planting is more certain of results than that done in the fall. The drawback to spring planting is that the work must be frequently delayed longer than is desirable because of unfavorable soil conditions, particularly upon heavy and retentive soils. Young plants suffer severely from heat and drought if they have not had an opportunity to grow and form considerable root before the hot period comes on.

In order to secure a uniform distribution of the seed, the seeding should be done in two directions. The seed should be divided into two lots, one of the lots being scattered in one direction across the land and the other scattered at right angles with the first. This is in order to obliterate as far as possible balks and streaks in scattering the seed.—(F. B. 248; B. of S. B. 75; O. Ex. Sta. B. 106; B. 138, U. of Ill.)

Maintenance of the Lawn.—A perfect lawn is one of the rarest possessions of either public or private establishments. A good lawn demands great skill and judgment in its maintenance as well as in its making. All the operations connected with the maintenance of a greensward are directed toward securing a uniform sod or turf over the entire extent of the lawn. In order to secure this the plants which constitute the lawn should be kept in a luxuriant, vegetative condition and never allowed to go to seed. There is no operation connected with plant life which is so trying upon the vitality as the production of seed. In order to keep a close, even surface over the area, it is necessary to use a mower frequently, but in using the mower the clipping should not be done close enough to deprive the plants of sufficient leaf area to carry on their normal functions. Upon newly established lawns the operation of clipping should not be delayed until the grass is too high. As soon as a mower with a blade 2 inches high will cut the ends of the leaves, the mower should be passed over the surface. By repeating this at close intervals during the growing season a better and more uniform stand of grass will be secured.

It is a mistake to allow a lawn to go in an unkempt condition during the first months of its existence. It should from the beginning be subjected to the same treatment which is to be carried on later in its life. It is not advisable to clip the lawn frequently during periods of drought, but even during these periods it is not well to allow the plants to produce seed stalks. The general plan of keeping a lawn clipped to a height of 2 inches is a very safe one to follow. The clipping, too, should be sufficiently frequent to prevent the necessity of raking off any considerable quantity of material after each clipping. If the soil is moist, very rich, and the growth luxuriant, it will be necessary to rake off the clippings, but on comparatively poor soils the clippings will not be detrimental unless they produce an unsightly effect. Before growth has advanced to any considerable extent each spring, the lawn, as soon as it is comparatively dry, should be gone over with a heavy lawn roller, so as to embed firmly any of the grass roots which may have been loosened by frosts and to reduce the surface to a uniform condition.—(B. 248; B. of S. B. 75; Ohio E. S. B. 106; U. of Ill. B. 138.)

TREES, SHRUBS AND VINES.

Trees.—Trees are a necessary part of making a perfect lawn. Their careful selection is as important as is the careful selection of seed for the grasses. Trees which shed their foliage at the approach of winter must necessarily form a large portion of the lawn trees in the North Temperate zone. The deciduous trees present a great range of size and form, as well as a great variety of colors and leaf forms, features of the utmost importance in producing variety in landscape effects.

Some trees are very sensitive to the cold, and will not grow well except in warm climates, while others do not bear extremes of heat well, so the climate must be taken into consideration in selecting trees for the lawn. Some trees require lots of sunlight; others flourish best in shaded or secluded spots; some need a good deal of moisture, while others love warm, dry places. The nature of the tree must be understood to make the right selection, and a tree that by nature loves shade should not be selected for spots where it will be subjected to the glaring rays of the sun. Soil also has something to do with the healthy growth, but not near so much as climate. The tree lives on light, heat, air and moisture and these it must have in abundance and properly proportioned if the tree is expected to thrive. It craves food and is always hungry.

Some trees are natural pirates—they will steal food from one another, and from a tree of another variety. A soft maple is to other trees what the English sparrow is to other birds. Hence in selecting trees all care should be taken to get trees of an average aggressiveness, so that each can fight for itself in getting food. Some trees produce a denser foliage than others. On lawns this is a great desideratum, as the leaves take up from the atmosphere heat and hold it. Thus they in a degree lower the temperature for some distance around them. The denser the foliage the more heat they take from the atmosphere.

Trees are nature's great sanitary agents. They collect and absorb the malaria that is in the atmosphere, and, absorbing it, neutralize it, thereby purifying the air. Some trees are greater consumers of malaria than others, and this should guide in the selection of lawn trees. The "winged elm" is a great absorbent of malaria. It is so bitter that no insect will molest it. It grows well and is a very bold tree, well able to take care of itself. Willows are also malaria eaters.

In tree selection nature is an excellent guide. The tree that is indigenous to the locality is likely to do best on the lawn. Oaks, elms, and sugar maples are beautiful lawn trees, but other varieties grow well and perform all the functions required of them.

Great care should be exercised in transplanting the trees. The young tree should be trimmed of all its branches, leaving nothing but the trunk. The hole, or pit, should be large enough to permit the filling in of a sufficient quantity of rich earth and manure; the whole should be well saturated with water; all the small fibers of the roots should be carefully spread out, and finally the earth be well tamped down around the tree so as to secure an upright growth. Shade being the principal thing wanted in lawn trees they should be closely pruned. This makes leaves. In planting care should be taken that a look of uniformity is lost. Planting in rows gives them a stiff appearance, and the landscape effect is injured. A beautiful sward being the most important feature of the lawn, trees and shrubs are but secondary and should be so planted as to assist the landscape effect without marring the sward appearance.

Shrubs.—Few shrubs possess a sufficiently graceful and characteristic habit of growth to make them pleasing objects when grown singly upon the lawn, but where a number of specimens of varying habit are brought together in a single group, the differences are emphasized by contrast and the variety produces a pleasing effect, particularly if the rate and habit of growth as well as the color and character of the foliage be somewhat different. Pleasing results in groups of shrubs do not come from large numbers of the same variety in mass, but from a harmonious arrangement of different genera, species, and varieties. In order to secure the greatest pleasure from shrubs in groups, each group should represent some idea either of spirit or of rest, and always of beauty. These effects come from the habit of growth of the plants used. Tall-growing, graceful, reed-like plants produce an effect of grace and beauty, while plants of a more sturdy habit may indicate strength and resistance.

Producing Color Effects.—Pleasing effects in shrubbery plantations come also from massing sorts so as to produce a floral display each month of the year. A group which blooms in May or June, and which presents no additional feature other than a mass of foliage from June until autumn, has little merit from a decorative point of view. Variety is the secret of pleasing effects in shrubbery groups. Glaring contrasts in habit of growth or in color of flowers or foliage are as objectionable in planted groups as in tapestries, but reasonable and harmonious contrasts only add beauty and variety to the landscape. Not only do the flowers and foliage of spring and summer contribute to these results, but autumn colors add a most desirable and valuable contribution to the season's panorama.

Shrubs should be studied not alone from the standpoint of the size, color, and profusion of their bloom, but the time of leafing should be noted. The color of the leaf during summer as well as in autumn is also important. But most important of all is the time the leaves fall, whether early or late, or whether they remain on all winter.

The position of a shrub is as important as its kind. There are two methods of arrangement. One is to plant them as individual specimens, just as one does with most trees, where they will develop their individual beauty. The second is to plant them so that they will just touch each other when developed, and when seen together make a mass rather than several individuals. Such a mass is usually more effective if the plants are all of the same kind. Mass planting is better than individual planting, when it comes to making picturesque effects. It harmonizes better with the entire picture without losing the characteristic beauty of the variety.

There are two kinds of ornament. One is to give a useful thing an ornamental form which is at the same time consistent with its use, as for example, a well-designed chair or table. The other is to add another object to it which shall do no work but help to make it attractive. Shrubbery and vines belong to this latter class. Shrubbery almost always looks best against a house or fence or near a drive or walk.—(B. 138, U. of Ill.; F. B. 185, 248; B. of Soils, B. 75; Y. B. 1902; Ohio E. S. 106; U. of Ill. 138.)

Vines.—Climbing plants meet a demand in the adornment of a place which can be filled neither by trees nor shrubs. Trees and shrubs can be used to hide unsightly objects from a distance, but vines serve the same purpose as the draperies of a garment; they mask by covering unsightly objects. Vines which attach themselves to wire or wood supports and are chiefly valuable because of their covering and shading effects are the clematis, with all its varied forms, the wistaria, the trumpet flower, and the Actinidia and Akebia, both valuable cover plants. For sandy regions either as a soil binder or as an arbor or trellis cover none of the vines is more useful than the Japanese honeysuckle (*Lonicera japonica*). There are many other good honeysuckles (Loniceræ) grown for decorative purposes, but none is more rapid growing or freer from insect pests and fungous diseases than the Japanese honeysuckle. In this catalogue of valuable vines two more of our native vines justly merit high places —the five-fingered ivy (*Ampelopsis quinquefolia*) and the bittersweet (*Celastrus scandens.*)

Annual vines may also serve a useful purpose about a new place. The perennial woody vines are slow growing, and usually make but little shade or protection during the first two or three years after planting. With annual plants, however, the case is quite different. Many annual climbing vines have a profusion of leaves, grow rapidly and luxuriantly, and afford a simple, inexpensive, yet satisfactory means of securing an immediate screen. For best results with these plants special attention to early planting, often indoors, is essential. When planting-out time arrives, place them in a rich, well-drained soil, and at all times maintain an abundant supply of moisture. Under such conditions use the moonflower. (*Ipomœa grandiflora*), the *Cobœa scandens,* the morning-glory, the cypress vine (*Ipomœa quamoclit*), the hyacinth bean (*Dolichos lablab*), nasturtiums for low screens and lattices, and the wild cucumber (*Echinocystis lobata*) for taller structures. Rustic summer houses and arbors may be very beautifully and satisfactorily adorned with cobœa, or with wild cucumber, during the time which must elapse before the permanent vines can be grown sufficiently to cover the structure.—(F. B. 185, 248; Y. B. 1902; B. of Soils B. 75; Ill. B. 138; O. E. S. B. 106.)

KEEP THE BOYS ON THE FARM.

It has been said that the cities would not last long were they not supplied with new brain and vitality from the farm. How many people have given serious consideration to the real meaning of this constant drain of the best brain from the farm to the city, which has been going on for many years, and its significance and serious effect upon the development of agriculture? The city has been developed to the neglect and at the expense of the country.

The familiar saying, It is hard to teach an old dog new tricks, is all too true. It is the young men in farming today that must be looked to for advancement and the improvement of the farm conditions and methods. How can the best boys be prevented from leaving the farm? There are three essential things which must be demonstrated to the average bright American farm boy to make him stay on the farm: first, that there are, on the whole, possibilities for as great an income on the farm, with the same expenditure of energy and brain, as in other callings; second, that farm life may be made attractive and robbed of its old-time drudgery; and third, that the honors to be attained by the farmer, and the recognition given him, are as great as in the professions in the city.

With the increased yields now being secured by the most progressive, and the practice of business methods, the man on a farm may have an income that will enable him to develop the other two requirements.

The Desolate Home.—No paint on the house, no honeysuckle over the door and no time or money for the comforts within that go to make a house a home—such conditions are far reaching in their degrading effects, especially upon children. No amount of schooling can drive the memory away or change the effects on the boy of such a home, for the picture that is burned into the boy's brain lives forever. Is it any wonder a boy reared under such conditions hates the sight of the farm?

One of the greatest problems before the American people has been how to interest in rural life and attach to the farm the young man who has acquired a liberal education and displayed a capacity for leadership. The loss of rural leaders by emigration to the city has been one of the most serious retrogressive factors in our whole civilization. The Farmers' Co-operative Demonstration Work has solved the problem. These young men left the farm because they were repelled by the hardships, excessive toil, and meager gains on the farm and were allured by a seemingly greater opportunity to acquire wealth, influence, and position in the city. The demonstration work undertakes to create in the schoolboy a love of the farm and a new hope by showing the wonderful possibilities of the soil when properly managed and the ease with which wealth and distinction are achieved in rural life when science and art join hands. This is worked out by the co-operation of the demonstration workers, the county superintendent of public instruction, and the rural teachers.

More intelligent, enthusiastic men on the farm, is a crying need in agriculture today. Our century can show no greater glory than the awakening of an intelligence in relation to the work of the farm. If this can be generally accomplished, it will be the biggest thing that ever happened. For real meaning it will surpass any educational movement that has yet swept any country, as the final result would be a saving of human energy which would be of even greater consequence than the conserving of our forests and mines.—(Ill. Col. B. 26; Y. B. 1909.)

MEAT ON THE FARM.

Nearly all farmers kill more or less meat for family use, especially hogs. To properly cure the meat for future use requires close attention and some skill. The following general directions will be found useful:

Casings.—Sausage casings are the intestines of hogs, cattle, or sheep which have been emptied and cleaned. They are turned inside out and soaked in a solution of lye or limewater, thoroughly washed, and then salted down. When cleaned and put up by a reputable packer they are as good as when cleaned at home, and when they can be bought at a reasonable price it hardly pays to clean them for home use. The casings from different animals are used for the various kinds of sausages. Beef casings are of three kinds, rounds, made from the small intestines; bungs, made from the large intestines; and middles, made from that part of the entrails leading from the bung to the rectum. The rounds are used for bologna, the bungs for bologna, ham, and blood sausage, and the middles for bologna and summer sausage. Hog casings are made from the small intestines of the hog, and are used mainly for pork link sausage. Sheep casings are from the small intestines of sheep, and are commonly used for wienerwurst and other small sausages.

Smoking of Meats.—Pickled and cured meats are smoked to aid in their preservation and to give flavor and palatability. The creosote formed by the combustion of the wood closes the pores to some extent, excluding the air, and is objectionable to insects.

House and Fuel.—The smokehouse should be 8 or 10 feet high to give the best results, and of a size suited to the amount of meat likely to be smoked. One 6 by 8 feet will be large enough for ordinary farm use. Ample ventilation should be provided to carry off the warm air in order to prevent overheating the meat. Small openings under the eaves or a chimney in the roof will be sufficient if arranged so as to be easily controlled. A fire pot outside of the house proper with a flue through which the smoke may be conducted to the meat chamber gives the best conditions for smoking. When this can not well be arranged a fire may be built on the floor of the house and the meat shielded by a sheet of metal. Where the meat can be hung 6 or 7 feet above the fire this precaution need not be taken. The construction should be such as to allow the smoke to pass up freely over the meat and out of the house, though rapid circulation is at the expense of fuel.

Brick or stone houses are best, though the first cost is greater than if they are built of lumber. Large dry-goods boxes and even barrels may be made to serve as smokehouses where only small amounts of meat are to be smoked. The care of meat in such substitutes is so much more difficult and the results so much less satisfactory that a permanent place should be provided if possible.

The best fuel for smoking meats is green hickory or maple wood smothered with sawdust of the same material. Hard wood of any kind is preferable to soft wood. Resinous woods should never be used, as they are likely to impart bad flavors to the product. Corn cobs are the best substitute for hard wood and may be used if desired. Soft wood and corn cobs give off large amounts of carbon in burning, and this is deposited on the meat, making it dark in color and rank flavored. Juniper Berries and fragrant woods are sometimes added to the fire to flavor the meat.

Filling the House.—Meat that is to be smoked should be removed from the brine two or three days before being put in the smokehouse. If it has been cured in a strong brine, it will be best to soak the pieces in cold water overnight to prevent a crust of salt from forming on the outside when drained. Washing the meat in tepid water and scrubbing clean with a brush is a good practice. The pieces should then be hung up to drain for a day or two. When drained they may be hung in the house. All should be suspended below the ventilators and should hang so that no two pieces come in contact, as this prevents uniform smoking.

Keeping Up the Fire.—A slow fire may then be started, warming up the meat gradually. During the winter months in cold climates it is best to keep the fire going continually until the smoking is complete, holding the temperature at about the same point. If the fire is allowed to die down, the meat becomes cold and the smoke does not penetrate readily. This results in heavy smoke on the outside and very little on the inner portions of the meat. During the spring months and in the summer a light fire may be started every second or third day for two weeks, the meat being allowed to hang in the smokehouse until sufficiently colored. When the fire is kept going steadily and an even temperature is maintained, twenty-four to thirty-six hours will be required to finish one lot of meat. Smoke will not penetrate frozen meat and it will be necessary to extract all frost from it before filling the house. The house should be kept dark at all times to prevent flies entering. As soon as smoked sufficiently the meat should be cooled by opening the ventilators or doors. When hard and firm it may be canvased or packed away for summer use.

Keeping Smoked Meats.—Smoked meat may be left in the smokehouse for some time during moderate weather. The house should be kept perfectly dark and well enough ventilated to prevent dampness. A dry, cool cellar or an attic with free circulation will be a satisfactory place for smoked meats at all seasons if it is kept dark and flies are excluded.

If to be held only a short time, hams and bacon will need only to be hung out separately without covering. For longer keeping it will be necessary to wrap them first in paper and then in burlaps, canvas, or muslin and bury them in a grain bin or other suitable place, the object being to gain a uniform temperature and to keep away insects. A coat of ground pepper rubbed into the piece before wrapping will be distasteful to them. For absolute safe-keeping for an indefinite period of time, it is essential that the meat be thoroughly cured. After it is smoked and has become dry on the surface it should be wrapped in parchment paper; or old newspapers will do where parchment can not be had. Then inclose in heavy muslin or canvas, and cover with yellow wash or ordinary lime whitewash, glue being added. Hang each piece out so that it does not come in contact with other pieces. Do not stack in piles.

Recipe for Yellow Wash.—For 100 pound hams or bacon take 3 pounds barytes (barium sulphate); 0.06 pound glue; 0.08 pound chrome yellow (lead chromate); 0.40 pound flour. Half fill a pail with water and mix in the flour, dissolving all lumps thoroughly. Dissolve the chrome in a quart of water in a separate vessel and add the solution and the glue to the flour; bring the whole to a boil and add the barytes slowly, stirring constantly. Make the wash the day before it is required. Stir it frequently when using, and apply with a brush.—(F. B. 183.)

RELATION BETWEEN PRODUCTION AND WAGE RATES.

Necessarily in the long course of time the employing farmer must depend upon the value of his products for the wages that he pays to his laborers. He can not go on indefinitely paying wages out of capital, but he must in the general experience pay them out of farm products. Hence it follows as a matter of inference that farm wages may be higher in those States in which the value of the products per worker is higher than in those States in which the value of products per worker is lower.

This conclusion is amply substantiated in the investigation of farm wages in 1909. The highest wages are paid in the Western division of States, and in this division the average value of farm products per agricultural worker in 1899 was $759. Next below this division in both rate of wages and average value of farm products per worker, $678, is the North Central division; and third in order in both respects is the North Atlantic division. The South Central division is fourth in order in both rate of wages and value of products per worker, which is $271; and last of all is the South Atlantic division in both respects, the average value of products per worker being $233. These values stand for gross amount of products, and not for net wealth produced.

Advantage of Farm Wages in Purchasing Power.—If the farm laborer is comparing his nominal rate of money wages with the similar rate of the motorman or conductor of the electric railway who lives in the city, he must take into consideration the less costly living that he gets on the farm. In some respects it is a better living, against which of course there must be made a set-off of features that are in some respects worse.

The farm laborer gets many things at prices which are as low as wholesale prices in the motorman's city, and sometimes lower. He can get his supply of poultry at low prices, if he does not produce it himself; and so with eggs, milk, and butter; sometimes flour and meal; very likely potatoes and other vegetables and fruit. At low prices he may also get fresh and salt pork, his fuel and, in many parts of the country, his tobacco. If he pays rent for his dwelling, he will pay, say, $40 per year, whereas the motorman with a family pays $150.

All things considered—the allowances received by the farm laborer supplemental to the money rate of wages and the lower cost of many things that he buys as compared with the cost in the city—the farm laborer receiving nominally $30 per month really gets, in comparison with his situation as it would be if he lived in the city, perhaps more than the motorman or street-car conductor gets, and very likely in most cases a larger amount than he would be likely to earn in any occupation open to him in the city.

The money wage rates of farm laborers have increased in a marked degree within the last few years, and in this respect a comparison may be made with the wages of workingmen. A still further comparison may be made between the purchasing power of the wages of the farm laborer in terms of food and the purchasing power of the wages of workingmen. The investigations of the United States Bureau of Labor make possible this comparison.

If the mean wage rates of agricultural laborers for the years 1890-1898 be regarded as 100, the rate per month of the outdoor labor of men on farms in hiring by the year and season in 1890 is represented by 100.9. The relative number increased to 103.6 in 1893, and there was a sudden decline to 96.3 in 1894, after which there was an unbroken increase in this number until in 1907 it was 141.1.

The purchasing power of the wages of the farm laborer in 1907 in terms of actual food consumption in comparison with the mean of 1890-1898 is represented by the comparative number 117.1. In 1907 the corresponding relative number standing for the wages of the workingman was 122.5 and the purchasing power of his wages in terms of actual food consumption in 1907 is represented by the relative number 101.7, as compared with the mean of 1890-1898 which, as before stated, is represented by 100.

As time advanced after 1890 the farm laborer, setting out with wages having a relative purchasing power in terms of food about equal to that of the workingman, passed him in this respect in 1899, and rapidly gained upon him in subsequent years.—(Y. B. 1910.)

COLD STORAGE.

Requirements.—The storage of fruits and vegetables is an important factor of correct and progressive farming—storage not only for market purposes but for home use. Perhaps the simplest way of storing the fruit or vegetables is to put them in a pit or cellar, but this method provides only imperfectly for ventilation and a low, even temperature, which are essential conditions in keeping fruit of any kind, while, for hygienic reasons, the storing of fruit under dwelling houses is not to be recommended. A certain amount of decay is inevitable, and the decaying fruit becomes a propagating place for disease germs which permeate the rooms above, frequently causing sickness.—(F. B. 119.)

The Cave.—The most common way of storing without ice is to utilize a pit or cave. Such pits or caves vary in details of construction, but the general principle is the same throughout. This primitive method of underground storage has the merit of being inexpensive, and while being adapted to small farms it is not equal to the demands of orcharding on an extensive scale.

Such a cave is usually constructed on a hillside, so that the entrance is protected from the winds that prevails during summer and autumn. In moist soils the cave must be walled, in dry soils no walls are required. Upright posts along the sides support the top, which is made of poles; over the poles is a layer of coarse hay, and over the hay, soil to the depth of 2 feet. Several flues are made for ventilation. Such a cave may be built any desired dimensions; some are with doors in each end and large enough to allow a passageway for a wagon through them. The best system of ventilation and the most even and desirable temperature can be maintained by use of an underground ventilation pipe leading from an opening in the floor of the cave to a similar opening on the surface of the ground several rods away. The pipe should be large enough to provide sufficient air for the cave and should have valves at each opening to regulate the supply. The air in passing through the pipe is cooled in summer and warmed in winter and thus brought to near the proper temperature for good results in keeping fruit. To complete the system several flues should lead through the top of the cave to the open air above. The sum of the capacities of these flues should at least be equal to the capacity of the ventilator leading into the cave.—(F. B. 119.)

Storehouse.—Another way, and one best adapted for the purpose where orcharding is more extensively conducted, is by means of a storehouse especially designed for such use. A storehouse in which no system of artificial refrigeration is employed is generally operated by admitting the outer air when its temperature is low enough and excluding it at other times. The walls of such a storehouse should be thick enough to preserve, as near as possible, an even temperature, and should be so constructed as to wholly exclude all air except through the ventilating shafts. In this system ventilation is the most important thing. The outlet of the ventilating shaft should have a trap so as to admit the air and at the same time keep out the storm. The main thing is to secure a good connection with the pure air on the outside. It is well to pack the walls between the outer and inner sheathing with fine shavings or sawdust. The cost of such a building will depend upon the dimensions, but one with a capacity for storing 300 barrels of apples was built on the New Hampshire Experiment Station farm at a cost of $80. Such a storehouse while adapted to the cold weather would be inadequate during the hot summer months.—(F. B. 119.)

Storing With Ice.—Almost every locality has its supply of ice which comes naturally in the winter, and this, if saved and utilized, would be a source of comfort and profit all the year. It can be readily done by co-operative methods. A small ice and cold storage building can be cheaply constructed and, where a supply of good ice can be depended upon, is to be highly recommended. Fruits, vegetables, meats and dairy products can be kept with excellent success in this way. Temporary structures for this purpose can be made very cheaply, but the cold storage house should be built with the view of permanence and continuous use.

The Building.—Much of the efficiency of the building for cold storage depends upon the insulation of walls, ceiling and floor. These parts should be constructed so that they will be almost non-conductors of heat. Hence, the use of mineral wool, sawdust, building paper and dead air spaces. These are all poor heat conductors. Air conveys heat rapidly by circulation, but where confined, so that the process must go on by conduction, it is very slow. On this account, still or dead air becomes one of our most useful insulating materials in cold storage construction.

Insulation.—The lumber for the insulation should be free from offensive odors. Pine is objectionable on this account. The outside lumber that comes in contact with the soil should be hard and durable. A coat of crude petroleum and a layer of tarred paper before the soil is banked will make it almost indestructible. The lower story may be made of stone, but the insulation will have to be provided besides, as a stone wall will allow the passage of heat very freely. The whole building, roof and all, should be painted white, in order to retard the absorption of heat from the sun. The interior of the storage house must not be subjected to rapid fluctuations in temperature. For this reason, the refrigerating room should have no door opening directly outside. If the storage room and ice chamber are filled with good ice during the winter, the quantity will be sufficient to last throughout the season. The ice in the storage room may be packed in chaff or sawdust, but that in the ice chamber should be without packing. When the ice in the chamber is exhausted it should be replenished from the storage room. After the building is supplied with ice in the winter the outside door should be packed with sawdust and not again opened. An inside ladder provides sufficient passageway into the ice chamber.

Advantages of Home Cold Storage.—1. The ice and cold storage house at the home provides a means of keeping products that are of daily demand in the home and on the local market; also those products that are quickly perishable but not of sufficient importance to be sent to the city warehouse. Butter, milk, eggs, poultry and fresh meats of all kinds can be kept in summer without deterioration; while the summer fruits that decay rapidly under ordinary conditions can be kept in cold storage and used or sold at pleasure.

2. With cold storage at home fruit can be stored quickly and without the injuries caused by shipping. This is of especial importance if it is to be sold on the local market. The shipping of fruit injures it unless the most extreme care is taken. Fruit is often shipped to distant warehouses and, after the storage season, is shipped back to the same locality from which it came. This would be avoided by home cold storage. Fruit should be stored as soon as taken from the tree. This is impossible when dealing with distant warehouses, but possible where we have home cold storage.

3. Fruit in home cold storage can have the constant personal care of the owner. He can examine it when he wishes and sort when necessary; he can sell it by the bushel or barrel in a week or a month and pay no extra storage fee.

4. Should the commodity deteriorate in quality, or the price fail to advance, the owner is out nothing for transportation and little for storage.

On the other hand city cold storage by farmers has several advantages which, to the commercial grower, are very important:

1. It is nearer the market, where it can be disposed of on the shortest notice. This enables the holder to take advantage of a sudden turn in price for the better. By use of the telephone or telegraph he can dispose of his whole crop in a few minutes.

2. By storing in city warehouses, fruit does not usually have to be shipped after it has been in storage. Shipping after storage is an injurious process and should be avoided. But if it must be done, the facilities for loading in the large warehouses are such that the fruit need not undergo change of temperature or injury. Adjoining the storage rooms are loading sheds which are kept very cool. The refrigerator cars in which the fruit is to be shipped are run into the sheds and the fruit is taken from the storage room directly into the cars, which are already cooled to a low temperature.

3. Fruit in city warehouses is practically on exhibition all the time, and if it is of superior quality it is a standing advertisement for the owner. Buyers find out to whom to look for such fruit. Commercial reputation and standing is no small thing in these pushing times. A man must not only grow fruit of first quality, he must make it known that he grows it. He will profit by storing it where buyers can find it.—(Kan. Ag. Col. Bul. 84.)

FARM IMPLEMENTS AND MACHINERY.

Historical.—The most prominent feature in the development of American agriculture is the immense improvement that has taken place in agricultural methods and machines—indeed, the word improvement is not adequate to express the change that has taken place in the methods of agriculture in this country, because the implements and machines are creations rather than improvements, and their mission has been radical and far-reaching. They have reduced the amount of human labor required to produce a given quantity of crops and to cultivate given areas of land, and they have been largely, if not chiefly, instrumental in converting local markets into world markets for the principal cereals, cotton, tobacco, and animal and dairy products.

A technical description of these implements and machines can not be attempted and it will be sufficient merely to indicate generally changes in their character and in the results of their work. Dependence must be placed upon the reader's knowledge of these machines and upon his mechanical mind to understand how and why they have contributed so much to the realization of the present agricultural era.

Vehicles.—At the beginning of the last century carts were used on the farms and chaises on the roads. Stagecoaches were used on the main roads of travel, and a few wagons were found here and there. Carts were more convenient for use with oxen on the farms. For many years discussion was active as to the comparative economy of oxen and horses for farm use, and wagons came in with the increased use of horses and the improvement of the country roads. Buggies and trotting horses grew up together. Light one-horse wagons first appeared in Connecticut about 1830, but it was not until 1840 or later that they became common enough not to attract notice when seen on the roads.

Plows.—In 1637 there were but 37 plows in the colony of Massachusetts Bay. Twelve years after the landing of the Pilgrims the farmers around Boston had no plows, and were compelled to break up the ground and prepare for cultivation with their hands and with rude and clumsy hoes and mattocks. It was the custom in that part of the country, even to a much later period, for anyone owning a plow to do the plowing for the inhabitants over a considerable extent of territory. A town often paid a bounty to anyone who would buy and keep in repair a plow for the purpose of going about in this way.

The first patent for a plow was issued in 1797 to Charles Newbold, of New Jersey. It was the first cast iron plow ever made, but the farmers entertained great prejudice against it, believing cast iron would poison the land. It was not until 1870 that any marked improvement came in the manufacture of plows, when the Oliver chilled plow came on the market.

Then invention followed invention until now there are the sulky plow, gang plow, plows combined with harrows, cultivators and seed drills, side hill plows, vineyard plows, sub-soil plows, double landside plows, and lastly, the greatest of all, the steam gang plow combined with a seeder and harrow, which has reduced the time required for human labor (in plowing, seeding and harrowing) to produce a bushel of wheat from 32.8 minutes in 1830 to 2.2 minutes at the present time, and has reduced the cost of human and animal labor in plowing, seeding and harrowing per bushel of wheat from four cents to one cent.

Corn Planters.—Hundreds of patents have been issued for corn planters. The earlier ones were adjustments to the hoe, which permitted the release of grains of corn when the hoe was struck into the ground; then came the hand planter, and the next step was the horse drill. Next came the idea of marking rows in both directions with a drag. A long beam with pins in it was dragged both ways across the field by horses, and then the farmer would go along with the hand planter and plant the corn at the intersection of the rows. Still, again, followed an improvement, and this was the corn planter which planted two rows at one time with the rows running in both directions. A man sat on the machine, and, at every point where the drag had crossed at right angles, he moved a lever that dropped the corn, which was covered by wheels that turned and pressed down the soil upon the seed. The check rower followed; it was a simple implement, consisting of a wire chain or knotted rope stretching across the field and anchored at both ends. This passed through the machine as it was driven across the field and dropped some grains of corn every time the knot passed through a slot in the machine. It was only necessary to drive backward and forward all day long until the acres were planted, and then the corn could be cultivated in both directions. Subsequently, numerous check-row planters for corn have been invented with and without fertilizer adjustments, so that several rows of corn may be planted at the same time in places at regular distances apart, permitting cultivating in both directions.

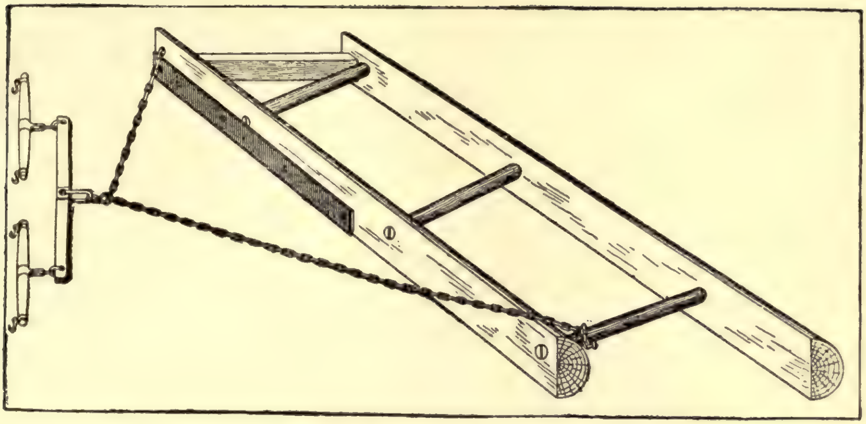
Cultivators.—Cultivators have been the subject of several thousands of patents. The original cultivation of corn and other crops planted in rows was by means of the hoe, but in the course of time a plow was used to loosen the earth and to suppress weeds and grass, being drawn twice between the rows and turning the soil against one or the other. Next a tooth harrow was employed, and this was drawn one way between the rows, and afterwards a cultivator with small double plowshares was used. Then followed the double-shovel cultivator, cutting deep or shallow, as desired, and turning the earth toward two opposite rows at the same time. The implement is now variously made, but it has reduced the economy of cultivation apparently to a minimum; the farmer may now ride while the cultivator is doing its work. He cultivates the rows of his crop in both directions, and the use of the hoe has been nearly, if not entirely, discontinued throughout large agricultural areas.

Harrows.—Much attention also has been devoted to the invention of implements for harrowing and pulverizing the soil. The farmer no longer drives a brush harrow over his field as of yore, nor does he need to use a tooth harrow, but he has at his command disk harrows, screw pulverizers, smoothing harrows, spring-tooth harrows, and harrows combined with plows and seeders.

Corn Husker.—The mechanical corn husker is a machine of recent invention. Previously the husking of corn was done only by hand, and a peg strapped to the hand was often used for opening the husks; but there is now a machine that husks the corn and at the same time cuts the husks, stalks and blades into feed, the motive power being steam.

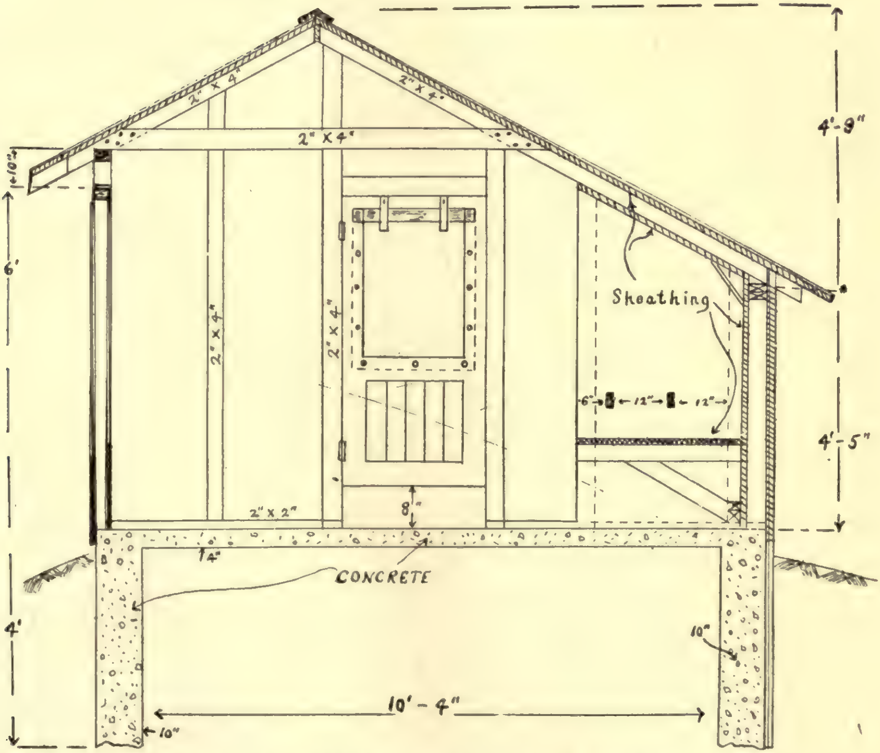
Corn Harvester.—Again, we have the recent corn-harvesting machine drawn by horses that cuts the cornstalks and binds them into bundles at the same time.

Cornshellers.—The steam cornsheller caused a remarkable change in the time and expense of the shelling of corn. In the olden time corn was shelled by hand, a frying-pan handle or shovel being used, the ears of corn being scraped against it, or perhaps the cob of one ear was used to shell the corn from another. Then came the first machine for shelling corn, a cylinder turned by a crank, by which a man might shell about 40 bushels in a day. Thousands of patents have been issued for cornshellers, and the culmination of them is the steam-power or horse-power cornsheller, which will shell



Perspective View of Split-Log Drag. Dept. of Agr.

(See page 151.)



CROSS SECTION OF WELL CONSTRUCTED POULTRY HOUSE

a bushel a minute, carry off the cobs to a pile or into a wagon, and deliver the corn into sacks or wagons.

Seeders.—From the time when wheat was first sown, up to a comparatively recent period, the only method of sowing it was to throw it into the air by the hand. In this way it is impossible to sow evenly, especially if the wind blows with considerable force; and if clover seed is to be sown, the ground must be gone over a second time, while a third time is required if fertilizer is to be distributed. Then, when the harrow comes some of the grains are buried too deeply and some are not covered with earth enough. But not so many years ago inventors set to work to construct mechanical seeders, and the result is an almost complete abandonment of broadcast sowing by hand and the substitution of such seeders. They sow all kinds of grain and seeds at once, with fertilizer if required, and they harrow at the same time. They make the crop more certain. It is the general opinion that the wheat crop is increased one-eighth or more by the use of the mechanical seeders, especially in the case of winter wheat.

Mowers and Reapers.—In 1794 a Scotchman invented what was described as a most marvelous and wonderful machine for cutting grain, doing as much in one day as seven men could do with the sickle. This marvelous machine was only the cradle. The reaper followed, and the first patent for one issued in this country was given to Hussey in 1833. McCormick took out his first patent in 1834, although he had constructed and tested a machine in Virginia in 1831 with some success; but the world heard little of reaping machines until 1845, when 150 of them were built at Cincinnati; by 1846 fully 300 had been built. There was a general trial of mowers and reapers at Geneva, N. Y., in 1852. Nine machines contested, for other inventors had taken out patents. Nineteen years had passed since the first patent had been issued. Out of the nine machines exhibited, not one could start in the grain without backing to get up speed. There was a heavy side draft, the machines were clumsy, and they could not turn easily.

By 1855 about 10,000 mowers and reapers had been built by different makers, nearly all being one-wheeled machines. There was an exhibition of reapers at the French exposition in 1855, in which there was one English, one French, and one American. The French machine did its allotted work in 72 minutes, the English in 66, and the American in 22.

Two years later, in 1857, there was a trial at Syracuse, N. Y., at which nineteen machines contested. Of these, all except three started in the grain without backing to get up speed. There was a trial at Auburn, N. Y., in 1866, at which forty-four different machines were entered, and of these, forty-two did their work in a satisfactory manner.

The mower and reaper combined cut the grain and left it on the ground bunched up in proper size for a sheaf subsequently to be bound by hand. The harvester was supposed to be an improvement upon this, because it had a place for one or two men to ride to bind the grain as fast as it was cut; but the self-binder went beyond that and by means of a mechanical attachment did the binding without the aid of human labor. It was not until 1870 that the self-binder was a mechanical success; but that was not the end of invention for constructing machines to harvest wheat.

It remained for the ingenuity of man to construct a combined reaper and thrasher, with which it is necessary only to drive across the wheat field in order to obtain the grain ready for transportation to the elevator or elsewhere.

Cotton Gin.—Without the cotton gin it would be practically impossible to raise and market the cotton crop of this country, which now commonly amounts to 10,000,000 bales and more annually. Before Whitney's invention it is said that the labor of one person was required for about ten hours to pick the seeds from 1½ pounds of cotton lint. At the present time one machine will gin from 1,500 to 7,500 pounds of lint in the same time, the quantity varying according to the size and power of the gin.

The development and creation of agricultural implements and machines by the inventive genius of this country is one of the most remarkable features of progress of the century. Its history is one of evolution and revolution—a revolution of incalculable consequences to human labor and the production and distribution of wealth, with an immense bearing upon the trend and character of industry, social life, and civilization.

It is no longer necessary for the farmer to cut his wheat with sickle or cradle, nor to rake it and bind it by hand; to cut his cornstalks with a knife and shock the stalks by hand; to thrash his grain with a flail, nor to drive horses over it to tread it out, nor to scrape the ears of corn against a shovel or the handle of a frying pan. It is no longer necessary for him to dig potatoes, nor to cut his grass with a scythe and to spread it with a pitchfork that it may dry, nor to pitch the hay from the wagon to the haymow in the barn, nor to pick the lint from cotton seed by hand, and so on with numerous operations throughout the whole range of agricultural work.

Mechanical contrivances have largely supplanted human labor in many respects, or have improved the application of labor and increased the product of agriculture, reduced the cost of production, augmented the farmer's gross income, and made his life an easier one than it was before the machine period.

This country has come to be without a peer in the manufacture of agricultural implements and machines, both in quality and number. The manufacturing establishments for producing them in 1890 numbered 910, with a capital of $145,313,997 and 42,544 employees, receiving wages to the amount of $21,811,761, turning out a product valued at $81,271,651. One of these establishments (the largest in the world), making various kinds of mowers and reapers, corn harvesters, corn huskers and shredders, and hayrakes, turned out 187,760 machines in 1898, or, on an average, one in less than a minute for every working day.

Saving in the Cost of Producing Crops.—The potential saving in the cost of human labor on account of improved implements, machines, and processes, at the rate per bushel or ton, as the case may be, has been computed for seven of the principal crops of 1899; the comparison is between the old-time methods of production, in which hand labor was assisted only by the comparatively rude and inefficient implements of the day and the present time, when hand labor has not only the assistance of highly efficient and perfected implements and machines, but has been considerably displaced by them. The saving in the cost of human labor in cents, per unit of product, permits a very forcible statement of its equivalent in money by means of a computation consisting of the multiplication of the saving per unit into the crop of 1899. The result expresses the potential labor saving in the production of seven crops of that year, and is not an aggregate of the saving of human labor in the cost of producing the crops for all the years between the earlier and the later ones, during which time this economizing and displacement of human labor has taken place. In the case of the crop of corn, the money measure of the saving of human labor required to produce it in 1899 in the most available economic manner, as compared with its production in the old-time manner, was $523,276,642; wheat, $79,194,867; oats, $52,866,200; rye, $1,408,950; barley, $7,323,480; white potatoes, $7,366,820; hay, $10,034,868.

The total potential saving in the cost of human labor for these seven crops of 1899, owing to the possible utilization of the implements, machines, and methods of the present time, in place of the old-time manner of production, reaches the stupendous amount of $681,471,827 for this one year.

From 1855 to 1894 the time of human labor required to produce 1 bushel of corn on an average declined from four hours and thirty-four minutes to forty-one minutes. This was because inventors had given to the farmers of 1894 the gang plow, the disk harrow, the corn planter drawn by horses, and the four-section harrow for pulverizing the top soil; because they had given to the farmer the self-binder drawn by horses to cut the stalks and bind them; a machine for removing the husks from the ears and in the same operation for cutting the husks, stalks, and blades for feeding, the power being supplied by a steam engine; because they had given to the farmer a marvelous corn sheller, operated by steam and shelling 1 bushel of corn per minute instead of the old way of corn shelling in which the labor of one man was required for one hundred minutes to do the same work.

In the matter of wheat production, 1894 being compared with 1830, the required human labor declined from three hours and three minutes to ten minutes. The heavy, clumsy plow of 1830 had given way to the disk plow that both plowed and pulverized the soil in the same operation; hand sowing had been displaced by the mechanical seeder drawn by horses; the cradling and thrashing with flails and hand winnowing, had given way to reaping, thrashing, and sacking with the combined reaper and thrasher drawn by horses.

Herein lies the strength of the horse as an economic animal. He has been assailed by the bicycle, the electric street and suburban car, and by the automobile, but all combined have not prevented horses from increasing in numbers and in value. As a source of farm power and as a substitute for human labor in combination with machines, the horse's economic place on the farm is more strongly established than ever before.

Spraying.—Machines for spraying are coming into general use for the destruction of insects and weeds, and many different machines are on the market. Without spraying machines commercial orcharding would practically be a failure.

The adoption of steam-power spraying has been a necessary and expected outgrowth of the remarkable extension in the use of hand spraying machines. At the time when the investigation of the cotton caterpillar of the South was begun, just before 1880, practically no spraying machines were on the market. There were one or two bucket pumps, which, however, were not especially designed for work against insects, and one or two cumbrous knapsack apparatuses for use against the Colorado potato beetle had been devised. The investigation of the cotton caterpillar resulted in the invention of a number of machines for field distribution of liquid poisons, and above all in the production of the "Eddy-chamber," or cyclone, system of nozzles, which has since become so prominent in insecticide and fungicide work. The discovery at a somewhat later date of the value of liquid applications as fungicides with vineyard work brought about the invention and manufacture of a serviceable series of knapsack pumps, and the almost simultaneous discovery of the applicability of liquid poisons as a remedy against the codling moth and plum curculio in apple and peach orchards started the construction of hand spraying apparatuses on a larger scale and mounted upon wheels for orchard work. A still later outgrowth in this line of work is the adoption, although as yet to a slight extent, of horse-power attachments, bringing about a spray through the slow progress of the horse through the orchard.

Among the first power spraying machines to prove successful was one invented in California. The pump for delivering spray material is of horizontal, double-cylinder, plunger type, capable of working against a pressure of 250 pounds to the square inch, and is operated by a 1-horse power gas engine. A large tank of 100 gallons capacity contains spray fluid, a small square tank contains gasoline sufficient to run the engine one or two days, and the other tank contains water, which is circulated by a small pump around the cylinder of the engine, thence through a coil inside of the main tank, where it is cooled, then back into its own tank.

In the rear of the pump is an air chamber and a pressure gauge, and at the extreme end of the platform are connections with stopcocks for four or more lines of hose. Forward from the air chamber runs an overflow pipe into the supply tank, having in it an adjustable relief valve, which maintains a normal pressure when some of the spray nozzles are shut off. The overflow is delivered through two nozzles set at an angle, thus keeping the mixture continually agitated.

In order to obviate frequent stoppage for the purpose of refilling the tank, the machine is provided with a tender—a 50-gallon tank hung between low, broad wheels and drawn by one horse. On the left side of the machine is a rotary pump driven by a belt from the engine, running over a friction clutch pulley, the discharge pipe of this pump being carried into the top of the main tank and the suction extending below the bed of the wagon. The spray material is mixed in the tender, which is driven alongside the machine, and connection made by a length of suction hose to the rotary pump; the pump is thrown into gear, and in two minutes the 50 gallons of mixture is transferred to the main tank without interfering in any way with the work of the sprayers. The spray nozzles are placed on the ends of extension rods of one-eighth or one-fourth inch pipe covered with bamboo, each rod having a globe valve at its hose end. The usual crew consists of six—four sprayers, a driver, and a boy to drive the tender. In ordinary work two rows of trees are sprayed at a time, two men to a tree, but if the trees are very large eight sprayers may operate economically.

There are a number of other steam spraying machines on the market, but it is not likely that the proprietor of a reasonably large orchard will go to the expense of first cost of constructing a steam spraying apparatus when he already has one operated by hand which accomplishes the work economically and with a reasonable amount of expedition. There is a geared automatic sprayer successfully used in a large Virginia orchard. It is a simple apparatus which sprays by means of an automatic gearing, the motion of the wheels of the tank cart operating the pump by means of a gear chain and sprocket wheel. One spray can be directed at the top of the tree and the other at the bottom. In this way one side of an entire row is quickly treated.

The steam apparatus in orchards, however, will be used to a large extent. A man with a small capital and some mechanical skill has a chance to make money as a public sprayer in a fruit growing region, and the use of the steam sprayer will likely be developed along these lines.

The steam sprayer is coming into larger use now that forest conservation is attracting so much attention. Many forestry clubs have supplied themselves with a steam apparatus. In some cases large road engines are used coupled to an ordinary street watering tank in which the spraying mixture is kept in solution. Small gasoline engines have also been used successfully. The motor and pump of a gasoline machine will weigh about 300 pounds. The fuel for a day's work can be carried in a gallon can. They are much in favor with cities for use in public parks, and will prove equally successful in orchards or in forest reserves.

Machines for Preparing Stover.—Machines are in use which husk the corn and shred the stover at the same time. Many have pronounced them economical, while some have questioned the advantages to be derived from them. Professor Nourse, of the Virginia

Experiment Station, who has recently given one of these machines a practical trial, reports very satisfactory results. He says the fodder is either cut by knives or torn into small bits by the shredder heads. We value the machine particularly for the improved condition in which it leaves the fodder. Any machine that will thoroughly shred the fodder is preferable to one that simply cuts it. Fodder that is shredded immediately on being drawn from the field is often so moist as to mold when thrown in large piles, and proves worthless for feeding. The New Jersey Experiment Station has reported serious trouble from this course. On the other hand, if the fodder is stored for a few months previous to shredding, the danger is largely, if not entirely, avoided. This involves considerable extra expense, however, which sometimes renders it of doubtful economy. The fact remains that stover can not be shredded in any large quantity when moist without great danger of its rapidly becoming unfit for feeding. Farmers having power cutters of their own can shred at one time sufficient for a week's use without danger of its spoiling.

Machines for Wheat Cultivation.—The use of steam as a substitute for horse power in plowing, in harvesting, and in thrashing wheat has not materially contributed to economy, except from a saving due to the elimination of animal power, so the more common power supplied by horses is here selected for the comparison. The years in contrast are 1830 and 1896.

It is one of the marvels of the age that the amount of human labor now required to produce a bushel of wheat from beginning to end is on an average only 10 minutes, whereas, in 1830, the time was 3 hours and 3 minutes. During the interval between these years the cost of the human labor required to produce this bushel of wheat declined from 17¾ cents to 3 1-3 cents.

In the contrast thus presented the heavy, clumsy plow of the day was used in 1830; the seed was sown by hand, and was harrowed into the ground by the drawing of bushes over it; the grain was cut with sickles, hauled to a barn, and at some time before the following spring was threshed with flails; the winnowing was done with a sheet attached to rods, on which the grain was placed with a shovel and then tossed up and down by two men until the wind had blown out the chaff.

In the latter year, on the contrary, the ground was plowed and pulverized in the same operation by a disk plow; the seed was sown with a mechanical seeder drawn by horses; the reaping, thrashing, and sacking of the wheat was done with the combined reaper and thrasher drawn by horses, and then the wheat was ready to haul to the granary.

The changes that agricultural production, especially the preparation of agricultural products for the market, have undergone within the last half century, and still more within the last quarter century, are remarkable and important. There is a great difference in results between the time when, as ascertained by the United States Department of Labor, 20 minutes of human labor were required to husk a bushel of corn by hand, with the use of a husking peg, and 102 minutes to haul the stalks required to produce a bushel of corn to a barn and cut them into fodder, and the time, as at present, when 17½ minutes are sufficient to haul the same stalks to a husker and, by the use of a machine operated by steam, to husk the corn and at the same time cut the stalks into fodder; and there was a transition from one agricultural age to another when a man ceased to expend 100 minutes of labor in shelling corn by hand, and employed a steam sheller by which a bushel of corn is shelled in a minute and a half. When farmers reaped their wheat with sickles and bound the straw by hand, hauled the sheaves to the barn and thrashed the grain with flails, these operations, applied to 1 bushel of wheat, required the labor of one man for 160 minutes, whereas this work is now done, by the use of a combined reaper and thrasher operated by steam, with 4 minutes of human labor.

Cultivation of Flax.—The lack of certain kinds of improved labor saving machinery has proved a serious drawback. Much has been written about flax-pulling machines, but it can not be said that invention in this direction has as yet been successful. The pulling of flax is essential to the production of proper spinning fiber. It is one of the expensive operations of the industry and a kind of labor that American farmers are averse to performing. Moreover, pulling flax is one of the foreign practices which many of our adopted farmer citizens leave behind them when they come to this country, many of them being even more averse to performing such labor than is the native American. The necessity, therefore, for a machine flax puller should be fully appreciated, and the need of an improved thrasher to remove the seed without injury to the straw is almost as urgent. A practical machine scutcher is another desideratum, for the fact remains that notwithstanding the many inventions of such machines that have been brought to public notice none have been successful.

Hemp.—In some sections hemp is cut with self-rake reapers or mowing machines, but in Kentucky, one of the great hemp-growing States, most of the hemp is still cut by hand with the primitive reaping knife or hemp-cutter, which is something between a corn cutter and a bush scythe. An experienced hand with a reaping knife will cut about one-half acre per day. With a sweep-rake reaper, under favorable conditions, from 5 to 7 acres may be cut in a day, and with a mowing machine, 7 to 10 acres. Hemp does not lodge like grain or heavy clover, but on windy days it is impossible to cut with either reaper or mower in the direction that the wind is blowing, for instead of falling back of the cutting bar the stalks drop down between the guards, where they are repeatedly cut off. The heavy, green, woody stalks, one-eighth to one-half inch in diameter and 8 to 14 feet tall, are much more difficult to handle than grass or grain, and they cause a much greater strain on the machine. Ordinary grain reapers are not entirely satisfactory for harvesting hemp; they are rarely strong enough. The experience of those who have used reapers indicates that a successful hemp harvesting machine of the self-rake type should be made especially strong, having a cutting bar not more than 3½ feet long, arranged to cut within 2 inches of the ground, extra heavy sections with rapid motion, and driving wheel with broader rim and larger lugs than are usually made for self-rake machines. Opinions differ as to whether two or three rakes give the best results. A team of four good farm horses is generally regarded as necessary for cutting hemp with a self-rake reaper.

Some form of harvesting machine must soon take the place of the hemp knife, since it is becoming more difficult to secure the skilled labor necessary to cut the crop by hand, and where hemp is raised on a large scale it is impossible through the slow hand methods to get it all cut at the proper time.

Hemp-Breaking.—Nearly all of the hemp is broken by hand breaks, such as have been in use many centuries. The crude heavy wooden breaks are all made by carpenters after one very simple pattern, and cost only $5 to $6 each. With one of these an experienced hand under most favorable circumstances can clean out about 250 pounds of fiber in a day. The average day's product of breaking is about 100 pounds of clean fiber. The work is performed by alternately crushing or breaking the stalks between the long jaws of the break and beating and whipping them over the break to free the hurds from the fiber. It is a slow process, requiring not only strength, but skill. The value of the product depends largely upon the skill of the laborer. There is considerable loss of fiber in beating it against the break to shake off the hurds, and with new and unskilled laborers this loss is often an item of importance. The principal objections to hand breaking are its slowness and cost. To break an average crop of 50 acres requires the services of 10 skilled hemp breakers for two months and costs at least $500. The hand break must give way to machinery.

Several machines have been devised for breaking hemp, but they have not given complete satisfaction. Very few of them have succeeded at all in breaking hemp in commercial quantities.

A machine consisting of a series of coarsely fluted rollers followed by a rapidly revolving spiked cylinder has been in use for some years in California and Nebraska. It breaks the hemp and delivers the fiber in the form of tow. This machine seems to be particularly well adapted to the preparation of fiber from tangled hemp stalks cut with a mowing machine.

In the hemp factories at Lexington there are machines consisting essentially of long series of corrugated rollers which are occasionally used for softening the fiber. It is said that these machines may be used for breaking hemp, but they are not actually so used. These and also the break used in California are too heavy to be taken into the field, and they require more power than can be furnished by an ordinary thrashing engine. Three decorticators have been in operation near Lexington, by which the hemp stalk is crushed in passing between rollers, corrugated for unretted hemp and smooth for retted. The hurds are then loosened by a rapidly vibrating mechanism, and the fiber is partly cleaned by a kind of carrier, which gives a rapid scraping motion. These machines break the hemp well and without waste or injury to the fiber, but do not clean out the hurds as well as is desired. They are portable, weighing only 2,000 pounds, and require only 6 horsepower for operation. An ordinary thrashing engine furnishes sufficient power to run two breaks. The hurds are used as fuel for the engine. The average day's output from each of these machines is 2,000 to 3,000 pounds of rough hemp. Attention is called to these machines especially, since they are the first portable machines that have proved successful, working out in the field and producing untangled long-line fiber similar to that cleaned on the hand break.

Reapers and mowers have revolutionized the harvesting of hay, oats, wheat and barley, and the old method of placing the hay in the mow by hand labor has largely been superseded by machines which lift a whole load from the wagon at one time. Profitable commercial raising of potatoes and onions would be impossible were it not for the machinery now in common use for planting, cultivating and digging. By the use of these machines not only is time and labor saved, but the yield is largely increased.

Selection of Machinery.—Intelligent selection of the correct type of machine for the work expected to be performed by it, is of the greatest importance. This point is too often overlooked by the farmer who is strongly prejudiced in favor of some particular make. When the correct type of machine has been selected, its size should be carefully considered. By the use of sufficiently large and strong implements, with large capacity, a great deal of time and labor is saved and the life of the machine is greatly lengthened. For example, on a fair sized field, a three section harrow will do one-half more work with the same amount of man labor. The teeth, having to travel less distance in harrowing the field, will remain sharp longer, and, consequently, the efficiency of the harrow is increased, while the time required for the work is decreased.

A man of ordinary ability can handle a two bottom gang plow nearly as easily as a sulky, or one bottom plow. By the use of the gang the capacity of man and plow are doubled, while the wear on each plow is only one-half what it would be on the single plow, were it made to cover the same number of acres as the gang. Then too, time is saved in case the shares must be taken to a shop for sharpening, as only one-half as many trips are necessary for the gang as with the single plow, for a field of equal size.

In selecting machinery, it is usually advisable to consider the matter of securing repairs. Repairs or new parts must be secured for nearly every farm implement some time, or perhaps several times, during the life of it. Usually, the repairs are not ordered until the implement will not run any longer without them and then they must be secured in a hurry. For example, the binder, mower, or other important implements or machines must be repaired at once, or the farmer may lose part of his crop while waiting for repairs. In this case, the question of being able or unable to secure the necessary repairs, may represent the difference between loss and gain on the season's crop. For such implements as are absolutely necessary during certain seasons, the owner should be able to get repairs on not over one day's notice, if not at once. Instances have occurred where the farmer was compelled to buy a new machine of another make simply because he was unable to get a repair for his old machine in time to do the necessary work.

Good visible oiling devices should be found on every farm machine. In selecting machinery this point should be kept in mind, as the life of the machine depends to a considerable extent upon whether or not it can be kept thoroughly oiled. Often all the necessary oiling provisions are made, but they are not in as plain sight as they should be and for this reason are likely to be overlooked.

Co-operative Ownership.—While on some farms there is too little machinery and horse-power used to properly cultivate the land and save human labor, on others there is too much. Careful statistical studies of farms in Minnesota have shown that horses are employed on an average only about three hours a day. At least two-thirds of their available energy, therefore, goes to waste, making the cost of the energy used very high. The same is true of expensive tools which are used only for a short period during the year. The interest on the money invested in them and the cost of deterioration and repairs considerably reduce the profits of production. A farmer needs to figure very carefully before investing in cornshellers, shredders, thrashers, power plows, etc., especially if the use of this needful machinery can be obtained by hire at a reasonable rate or co-operative ownership arranged. The latter method will doubtless be the final solution of the problem. There is, however, more to consider in the use of such machinery than the mere question of a few cents more or less profit. Freeing the man from slavish work in the process of production is the greatest thing and the greatest saving of all, even if it does cost more in dollars and cents.

Unnecessary weight and friction in the construction and working of machinery is also a cause of considerable waste of energy. American agricultural tools are much better in these respects than foreign tools, but great improvements, without sacrifice of strength or utility, might still be accomplished. The use of wide tires on wagons has made hauling easier and improved and packed rather than cut ruts in the roads. The farmer who still uses narrow tires for heavy loads is not only wasting time and horse energy, but is guilty of cruelty to animals and the destruction of the public highways. The relation between weight of load and width of tire and the maintenance of roads in each section should be carefully considered and fixed by local regulations.

Closely related to the healthfulness, convenience, and cheapness of farm buildings is the right selection, care, and use of farm machinery. The studies of pumping machinery have shown that the most important factor in its successful use is the mechanical skill of the farmer, and we are beginning to understand that the increased complexity and cost of farm machinery make the education of the American farmer along these lines more and more desirable.

No more significant change is taking place in American agriculture than the extent to which different kinds of motive power are taking the place of men and animals. The use of the traction engine and automobile in the place of the horse on the country roads, the employment of gasoline, steam, wind, and electric power to operate mowers, threshers, plows, feed cutters, corn huskers, and dairy machinery are illustrations of epoch-making changes that are now going on on every modern American farm. On one ranch in California there is $60,000 worth of farm machinery operated by some other power than animals or man. For want of proper information these changes are involving farmers in serious mistakes and large losses. They buy motors not suited to their requirements or which they do not know how to operate. They buy machinery not adapted to their condition and cause its rapid destruction by not knowing how to care for it.

There is made and sold each year in this country about $100,000,000 worth of farm machinery. Fully one-half of this goes into the hands of men who do not know how to select it wisely or to keep it in proper condition. The waste which results runs into millions of dollars annually. In addition, implement manufacturers lose large sums in making and attempting to introduce machinery unsuited to the work it is intended to perform, with a resultant loss to both farmers and manufacturers.

These facts emphasize the importance of co-operation among neighboring farmers in the purchase and ownership of farm machinery. Co-operation is the solution of the problem of the use of the heavier and more expensive classes of machinery, especially such as traction plows, combined reapers and threshers, and steam spraying machines, and may be profitably extended to some of the other classes. In sections where potatoes are the principal commercial crop, joint ownership of planters, cultivators, and diggers would prove economical. In all cases of community or co-operative ownership the use of the machines would be under the management of persons of mechanical skill and thus the successful operation and proper care of the machine secured. In many cities small manufacturing establishments combine together for the purchase and operation of a central power plant, effecting large savings in fuel, in wages of engineers and firemen and in the deterioration of a number of boilers and engines. Printing establishments combine in the ownership and management of presses and typesetting machines, and find such combinations economical and expeditious. Similar results would follow combinations among farmers. One traction plow would easily do all the plowing for an extended neighborhood, and traction reapers and mowers would as successfully do the harvesting. One steam sprayer would do all the spraying for orchards and forest trees for a large number of owners, and do it better. The operator would possess a knowledge of the proper mixture to use and the methods of application. One man skilled in the use of the ordinary gang plow will do more and better work than two unskilled men. One first class corn shredder, operated by men who understand the business will readily do all that class of work for a dozen average farms. The same is true of many of the other machines in use for farm work. The saving of time and labor to make farming successful necessitates the use of machinery, and the problem confronting the farmer is how to secure the use of that machinery in the best and most economical manner. Co-operation appears to be the solution. Co-operative ownership of farm machinery has been more thoroughly tested in some European countries than in the United States, and the results have been satisfactory.—(Y. B. 1894, 1895, 1896, 1897, 1899, 1901, 1904, 1908, 1910; Col. C. B. 167.)

FARM BUILDINGS.

The Home.—Many American farmers have seemingly acted upon the principle that the housing of the live stock on the farm is of far more importance than the housing of himself and his family. Hence his barn has been built with a view to the comfort of his horses and cattle, while the house in which he and his family must live, and in which the female portion of the family must labor, is wholly without conveniences and without proper light, heat and ventilation, thus shortening the lives of the family. He arranges the feed bins and chutes in his barn so as to lessen the number of steps he must take in feeding and caring for his stock, but too often nothing is done to lessen the number of steps of his wife. The most important of the farm buildings is the family residence.

Location.—One of the important features in the making of a comfortable farm home is the proper location of the house and general outbuildings. The grouping together of all the buildings may not be practicable on large farms, but those that serve for the comfort and convenience of the family should by all means be near each other. Where the buildings are already located it will be difficult to remedy defects, and about the only thing to be done is to accommodate improvements to present conditions. The saving of time, labor, and exposure to be gained by having the barn, and especially the stabling, reasonably near the house should not be lost sight of, and therefore suitable sites for these necessary buildings should be decided on before definitely locating the house site. Good soil about the house is also desirable. With good soil an attractive door yard is easily possible, and while the prospective builder may reflect that a few loads of manure will bring up the soil, he should also remember that both manure and the time to haul it may prove none too abundant, especially during the first years of his occupancy. The possibility of locating the kitchen garden conveniently near, and also the chicken house and yards, is worthy of consideration.

In selecting a location for a house there are certain points that should be held in mind. A slight elevation, having proper surface drainage, with protecting hills or woods on the north, is greatly preferable to a narrow valley, a low meadow, or the north side of a hill. The house should face so as to get sunlight into all the rooms, if possible, for where sunlight does not enter the doctor must. This may be accomplished by facing the house southeast, for example, instead of directly east or south.

There is another important view which should receive careful consideration when locating the farm buildings, and that is their relation to the general plan of the farm. With other considerations being equal, the buildings should be located so that all parts of the farm can be easily reached, and so as to avoid the loss of time in going to and from the fields.

Planning the House.—This must be largely controlled by the site selected, the style of the house to be built, and the limitation of cost; but there are certain rules applicable to all. The idea should be to build a house which is suited to its location and the surrounding country.

It is a common error to give little forethought to the placing of the buildings in their relation to each other, to disregard the outlook from the house, and to take no care in tree planting or to do no planting whatever. A complete and appropriate layout should be the starting point, and time spent in planning an estate will result in economy and beauty when the place is subsequently developed. If poorly planned it means a continued process of tearing down and reconstructing.

In planning a house it is essential that the rooms be located with a view to convenience in carrying on household tasks. More money should be put into conveniences than into size. Saving of steps and labor should have a controlling influence, with due regard to heat, light and ventilation.

Too much care and thought can not be devoted to the plan of the house itself. Generally speaking, no one is so competent to plan a comfortable, convenient house adapted to all his needs as the farmer himself, unless it be his wife, but it requires plenty of time and thought. To successfully plan a house one should be able to picture to himself every room and every passage.

There are three essentials that ought never be lost sight of in planning a house—to secure plenty of light, without injuring the exterior appearance of the house or interfering with the proper arrangement of furniture; to have it comfortably heated in cold weather, and at the minimum cost; and to have perfect ventilation at all times.

*The Kitchen.**—The ideal arrangement is to have the kitchen on the northeast corner of the house, where it will receive the early morning sunshine in winter and be protected from the excessive heat of the afternoon and evening during the summer months. For many reasons a southeastern exposure is most desirable for the dining room, with the library and living rooms to the west, where they will have the benefit of the evening sunshine. Provided the openings are properly screened, it is almost impossible to have too much light or ventilation in the kitchen.

In planning the kitchen special attention should be given to the location of the working facilities. The mistake is often made of providing a kitchen that is much too large for the purpose, necessitating many steps in reaching different parts of the room. The distance between the kitchen table and the cooking range should not exceed 6 feet. It should be borne in mind that if this distance is increased one step two extra steps must be traveled each time in going and returning. In the course of a day the housewife or servant may be made to travel miles in doing the work. The sink and drain board should be near a window where they will have plenty of light, and, if possible, they should be at one end of the work table. Even where water is carried into the kitchen by hand, a small sink is a decided advantage.

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* See also page 141.

If food must be kept in the cellar in summer time a dumb waiter with two or three shelves running from the kitchen to the cellar is well worth its cost. Of course, an ice box on the ground floor would avoid the necessity for keeping food cool in the cellar. If an ice box is used it should be so located that it can be conveniently filled with ice and yet be near the kitchen. Convenient cellar stairs are much less common than they should be, and their location, lighting, etc., are questions which should always be taken into consideration in house construction.

For use in cold weather there should be a pantry on the ground floor in which the food is kept, and this pantry should be within walking distance of the dining room and kitchen. If this is not possible, a box can be turned on its side and fastened just outside the kitchen window and the food kept in it.

If your house has been built without care to step saving in the position of dining table, sinks, and cupboards, a small table on rollers, especially if its capacity is increased by a lower shelf, will be found a great convenience. It can be used to advantage in setting and clearing the table. It is also helpful to have near the sink when the dishes are washed. They can be put on it and the table then moved to the china closet and emptied. Many a woman who is now tired of an evening would be fresh if she used a wheeled table and a high stool at the sink and work table.

The model kitchen has four windows. One whole side of the room is lined with cupboards, some with glass doors, others of solid wood; beneath are drawers and flour bins. The range stands conveniently near the work table, and there is also a large enameled sink with draining board. Between the large screened-in porch and the kitchen is placed the refrigerator, being filled with ice from the outside. The refrigerator doors open into the kitchen. Many times a day the cold storage has to be gone to, and this is an important matter, to have it right at hand. It will be found that there is not any more ice consumed in a summer than if the ice chest were in the cellar. Why should steps be multiplied in going to it? The kitchen in the labor-saving planned house is small. The more articles that can be reached with fewest steps, the lighter the work will be. A narrow kitchen is a great labor saver. One does not realize this until she prepares a meal in the large square old-fashioned kitchen; the extra steps count as miles in a day.

The general use of the sewing machine has saved the farmer's wife and other housekeepers unnumbered hours of labor, and in the same way the general use of the proper kitchen conveniences will prove equally advantageous. It is just as important to supply the farmer's wife with carpet sweeper, washing machine, bread mixer, and other labor-saving devices, and with sharp knives, egg beaters, measuring cups, and other kitchen conveniences as it is to use separators in the dairy or other modern appliances in general farm work.

The following is a general description of a model kitchen, with sanitary wall and floor coverings and kitchen furniture. A floor covering of oilcloth or linoleum is suggested as desirable, since it can be kept clean easily by mopping, and it does not require hand and knee work with a scrubbing brush. For best wear the more expensive sort is preferable, but even a cheap floor covering, which needs very frequent replacing, is preferable to a wood flooring, which needs more scrubbing. An oiled hardwood floor is easily cleaned, but is dark and unattractive. Tiling is clean, but harder for the feet than linoleum. A sanitary wall covering in imitation of tiling is recommended, which is applied like ordinary wall paper, and which is comparatively cheap, easily cleaned, and attractive. It must be carefully hung so that there may be no cracks or other hiding places for vermin. Metal tiling is perhaps more sanitary, but is also more expensive. It is, however, cheaper than true tiling and perhaps as satisfactory.

In this model kitchen a model kitchen cabinet, which provides many conveniences and has the advantage of grouping working materials at hand where they are needed, is placed where there is good light, next to the stove, on the one hand, and to the cold pantry, on the other, with the sink at the back. The stove is also placed where light is abundant.

When an engine is not used to supply the house with water, a small hand force pump should be placed in the kitchen. The pump should be connected with the cistern or well, so the housewife can obtain the water needed without going out of doors. In addition to the larger and more important facilities for lessening housework, there are several small devices, the greater number of which can be made at home at odd times and at a very small cost and which will go far toward the comfort of the persons doing the work. One of these is a ventilated window or outside cupboard for the keeping of meats, vegetables, and other necessaries of the kitchen. This cupboard consists of a sort of extension built on the side of the kitchen, generally occupying the lower half of a window, and is made of slatted blinds such as are used for window shutters. In fact, one pair of shutters cut in two in the middle will form the entire outer portion of the box. After nailing the blinds together a floor and roof are provided, and, if desirable, a shelf may be added about half way from the bottom. A top covering of tin or roofing paper is essential and should be put on over the boards. Before putting in the shelf the inside of this ventilated box should be lined with fly-screen wire to prevent flies and other insects getting in. After this device is installed in the lower half of a window it can be reached by simply raising the lower sash. By actual experience this has been found to be one of the greatest labor-saving devices that can be installed in the modern kitchen. When the kitchen is also used as the family laundry, stationary tubs of enameled iron or of soapstone should adjoin the sink. They should be covered to form a table when not in use, but as confined air near plumbing becomes dangerous the covers should close upon rubber knobs or wooden blocks, so as to leave an air space for ventilation. Nickel-plated union strips and hardwood-wringer holders should be added between the tubs and at the right hand end so that a wringer may be used. One of the needs of the ordinary farmhouse is a suitable place for the workmen to wash as they come from the fields. When a separate room is fitted up as a laundry, provision should be made here for the men by adding a large sink and bench.

The Bath Room.—The use of gasoline engines, now so common on American farms, makes it possible for all modern farm houses to be equipped with a bath room, so necessary for the comfort and the health of the family. But even on farms where the engines are not used, it is possible to have a bath-tub. A small tank in the attic, connected with the heater at the range will furnish an abundant supply of water for the bath room. A small hand force pump will refill the tank in a few minutes.

The bathroom should be a light, well-ventilated room with every facility for cleanliness. Floors and wainscoting of tile or composite material are most desirable, but painted walls are much less expensive and give excellent results. Tile is undoubtedly the most satisfactory material which can be used for the covering of the floors and walls where it can be afforded. Tile floor with covered base and walls finished with cement or hard plaster, painted with enamel paint, are much cheaper. When a tile floor can not be had, linoleum is an excellent substitute as it is practically impervious to water. It should be laid before the fixtures are set, in order that there may be no joints. Cement mixed with small chips of marble well rubbed down after setting makes an excellent floor, one that washes as clean as a porcelain plate and has no cracks to harbor dirt; the cost is only about twice that of a double wood floor, or 50 cents per square foot, including the necessary cement bed on which it is laid.

A porcelain-lined or enameled-iron bath tub is the best medium-priced tub. For supplying the tub with water a combination cock is best, allowing hot or cold water to enter the tub separately or the temperature to be regulated to suit the bather. The cocks should be placed high, so as to allow of water being drawn into pitchers.

The best lavatories are those of porcelain or enameled iron, with back and overflow all formed as integral parts of the fixture. The basin cocks through which the hot and cold water come are of various shapes, the simplest being the best.

The water closet is the most important plumbing fixture in the house, and should be selected and put up with particular care. A good closet should be simple, neat, and strong, of a smooth material, with ample water in the bowl. Among the modern closets there is none more satisfactory than the flushing-rim, siphon-jet closet, which can be had, including the trap, in a single piece of porcelain. Porce-

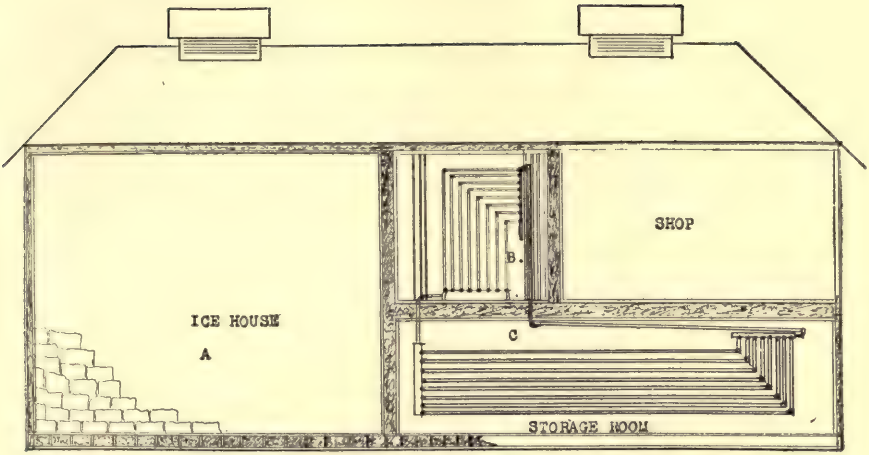
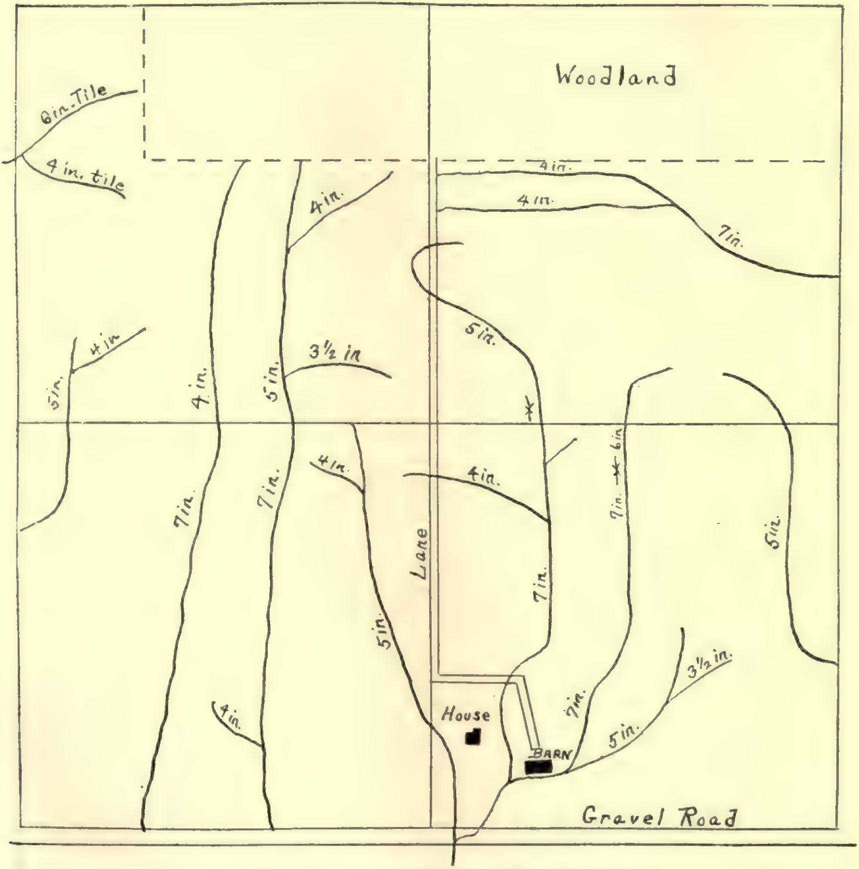


Diagram Showing a Combined Ice House and Cold Storage Plant. Dept. of Agr.



A System of Drainage. Dept. of Agr.

(See pages 258-276.)

lain is used because no other material can be kept so clean and sanitary. But even this is an imperfect protection from dirt and disease unless the bowl is flushed so as to clean it completely and absolutely. The water should be poured from the rim of the bowl, so that every part of it is perfectly cleaned. The wash-down and wash-out closets are similar in make, but are not so thorough in their action. In the wash-out closet the basin acts as a receiver, a small quantity of water being retained in it, and into this the deposit is made, to be washed out afterwards into the trap by the flush. The water in the basin is prevented from leaking into the trap by a raised ridge which is apt to break the force of the flush so that its whole force is not directed into the trap, which is objectionable. The wash-down closet receives the deposit directly into the water held in the bowl by the trap. It has a straight back and a much smaller fouling surface. There is no open vent. The outlet is entirely covered with water, so that the water does not throw the soil against the side. The only advantage the siphon closet has over it is the greater force of discharge given by the siphon.

Bed Rooms.—In planning the house the bed rooms should be so arranged as to be convenient to each other, and to have abundance of light and ventilation. They should be large enough to hold the furniture without crowding, and so arranged that the bed will have a place without crossing a window. Bed rooms should always be large enough to permit of being easily swept. As in all other rooms, ventilation is a prime factor in sleeping apartments. Closets are another necessity; they should be as large as possible.

The Living Room.—The living room should be made as light and cheerful as may be possible. It should be convenient in its arrangements and attractive in appearance, and in furnishings. A fireplace is a most attractive feature for the living room.

A fireplace will not furnish sufficient heat for a room in winter weather, but for spring and autumn a grate fire is all that is required. It is generally conceded that there is no better means of ventilating a living room than by a grate fire and no way of making a room more cheerful.

In recent years brick fireplaces, simply and honestly built, have grown in popularity. Brick can be obtained in beautiful shades varying from delicate cream to deep bronze. The ordinary paving brick in connection with stained woodwork gives excellent results. For large living rooms, charming fireplaces may be made of field stone or bowlders with heavy wood shelf and wood or stone brackets. In connection with interiors of a more dainty or elegant character, molded woodwork and tile facing may be used, or a mantel formed on colonial lines with marble, brick, or tile facing, and woodwork painted white.

The fireplaces should be 3 feet to 3 feet 6 inches wide and 2 feet 6 inches to 3 feet high and 20 to 30 inches deep. Cement makes admirable hearths and will withstand heat quite as well as tile or fire-brick. A suitable color could be mixed with the cement and the sand should have a good color. A smoking fireplace is a never-ending source of discomfort.

The Cellar.—In building the cellar enough windows should be provided for light and ventilation and a good-sized door opening outside. Double doors should be placed over the stairs leading up from this opening to the surface, and should be set at an incline that will readily shed water. The wall should extend around the space left for the stairs. In cold climates another and perpendicular door should be placed at the foot of the stairs, separating them from the cellar.

In the construction of the cellar the first thing is to provide such drainage as will draw off the water at least 1 foot lower than the surface of the cellar floor and prevent the ground air from passing through the walls and floors. In building the cellar walls every joint should be entirely filled with mortar. A good coat of asphalt over the outside of the wall turned in at the grade line with a course of slate or bluestone above ground level will prevent all soaking up of moisture. If a draintile is laid just outside the footing course and the space on the outside of the wall is filled with sand and gravel all the way up to grade, the surface water will be carried away through the drain.

The floor of the cellar is best made by a layer of brick or of cinder concrete, covered by a layer of asphalt and finished by a 4-inch layer of stone concrete. A layer of well-beaten clay makes a good cellar floor, but it can not be so easily kept clean. The height of the cellar walls above the ground is important. They should extend a sufficient distance above the ground to admit of windows in the cellar at least 2 feet high. This will insure plenty of light and thorough ventilation. There should be cellar windows on all sides of the house.

The cellar should be easily accessible from the kitchen and a stairway leading to the kitchen is an important feature. This stairway should be in a lighted portion of the cellar to avoid the danger of accidents. The fruit and vegetable bins should be so constructed as to be readily cleaned.

Porches.—In practical enjoyment in the summer broad porches pay a large interest on their cost. They should be made wide enough to accommodate seats or chairs and yet have space to move about. Such a porch practically adds an additional room to the house for summer use.

The floor should always be constructed of narrow, matched strips of heart wood, blind nailed, laid in white lead (the tongue of each strip heavily coated with white lead and oil before the next strip is driven on) and, if possible, with not less than three good coats of paint. The ceiling may be of matched and beaded 3-inch stuff or left open to the roof. The former will, of course, give a much more finished appearance.

An inclosed porch is the connecting link between the house and the garden. The plan of the house can be so arranged that this porch makes a convenient summer dining room. The planting of the trees, shrubs, and vines should be such as to give it privacy and a pleasant outlook. There is no reason why a backyard should not be a pleasant place. The part of the yard in daily use should be kept in a sanitary condition at least and, with proper attention, it can be made very attractive. Uncut grass, decaying vegetables, weeds, and stagnant water, to breed mosquitoes, are surely unnecessary.

A climbing vine often adds much to the beauty of the porch, furnishing an agreeable shade from the rays of the sun, yet for the most perfect enjoyment the porch should have an unobstructed view of all the surroundings. This view of the highway tends to lessen the feeling of isolation that so frequently makes farm life monotonous. The isolation of farm life has been one of the drawbacks to farming, and has sent many sons and daughters of farmers from the country to the city. Cheerful surroundings break this monotony, and the family loses the sense of isolation, and there is nothing about the house which more tends to give this air of cheerfulness, especially in the summertime, than a broad, well shaded porch.

The Windows.—Wide windows were always preferable to narrow ones, even though there be fewer of them. Great care should be exercised in placing the door and window cases to see that they fit snugly and leave no spaces for rain or drafts to enter the walls or rooms. The sash should be of the style known as check rail and glazed with double-strength glass.

In the colder parts of the country double or storm windows should always be provided for winter use. The amount of fuel they will save and the additional comfort they afford will amply pay for them. They can, of course, be provided at such time subsequent to building as convenience may dictate. For use in the country nothing has been found that answers every purpose so well as outside blinds. In preparing specifications wrought-iron hinges should be indicated. They can now be bought practically as cheap as cast iron, which they wiil outlast three to one. In exposed localities or where high winds are frequent some form of fastenings to hold the blinds open in addition to the usual catch on the hinge will be required. A simple device is made to drive into the wall. It has a swivel end, which stands upright by its own weight and holds the blind open except when turned to permit of closing. In windy situations these catches will save many hinges and possibly some glass.

The Floors.—In every case where it is at all possible, a double first floor should be laid, at least in all but the mildest climates. The first floor may be of comparatively rough stuff, but must be brought to an even thickness and laid diagonally. If possible use 4-inch matched flooring for this floor. It should be tight and smoothly laid, butting well onto the sills, so that nothing can get between it and them. It will prove a convenience if laid as soon as the sills and floor joists are completed. In completing the building after the plasterers have gotten through their work, this floor should be covered with a layer of good building paper and 1 by 2 strips nailed on top of that and immediately over the joists, and then a thoroughly dry 3-inch matched floor laid on the strips, blind nailed and butting squarely against the grounds. This method will give a thoroughly satisfactory floor, and the extra expense will be soon saved in fuel, the amount of cold excluded being almost beyond belief. Such a floor finished with some good filler and an oil finish need never be carpeted, will be easily kept clean, and will prove far warmer than the ordinary floor with carpet and carpet lining. Under all circumstances rugs are to be preferred to carpets.

Hardwood floors are in the end more economical; in addition they are more easily kept clean and in a sanitary condition. Carpets are now almost universally discarded, and hardwood floors with an occasional coating of oil that can be readily applied with a mop made for the purpose, are not only artistic but entirely sanitary.

Screens.—Flies and other household insects not only make work for the housekeeper, but are active agencies in the spread of disease, and there is every reason why they should be kept out of the house by screens at windows and doors. Much may also be done to prevent the breeding of such insect pests. Proper drains and other sanitary conveniences not only lighten the housekeeper's duties, but are also of the utmost importance in the hygiene of the home.

One phase of sanitation very frequently neglected by farmers is that of protecting the home from insects. Not only should the dwelling be properly screened, but precautions should be taken to avoid the formation of breeding places for flies and other insects. Flies breed principally in stable and chicken manure, and the only proper method is to keep the stable and poultry house clean. The floors of the latter may be sprinkled with land plaster, or fine dust from the roadway will answer. All pails and other utensils used for handling milk should be promptly cleaned and all refuse should be removed from about the dwelling to prevent flies finding suitable food. Anything that will attract flies to the house is a menace to health, for it has been found that wherever flies are abundant about the doors they gradually find their way in despite precautions. Mosquitoes breed in rain-water barrels, old tin cans, or any receptacle that holds stagnant water, and the careful elimination of breeding places will go a long way toward personal comfort in the home. A slight film of kerosene or other light oil over the surface of standing water will prevent the breeding of mosquitoes.

The efficiency of window and door screens depends largely upon their proper arrangement to prevent flies and other insects being driven into the house as persons enter. A screen door should always open outward, and should be so hinged that flies will not congregate on an adjoining wall where they can easily enter as the screen is opened; the door should swing so that the flies will be behind it when opened. Window screens should either cover the entire window or fit tightly below the upper or outside sash.

Painting.—This is an extremely important portion of the work of building the house, far more so than seems to be generally considered. Not only does the good appearance of the house depend very largely upon the painting, but its durability and comfort as well. The best siding manufactured will deteriorate rapidly if left unpainted, posts and pillars will crack and check, and warping and shrinkage will make entrances for wintry blasts. The work of painting can sometimes be done quite as well by the farmer himself, but too often he reserves too much to be done by himself, and months elapse before he succeeds in accomplishing this very necessary work.

Whether he performs the labor himself or hires it on contract, it will almost invariably pay him to purchase his own materials. By so doing he can be certain of their purity as well as of buying at the lowest price compatible with good goods. There is on the market a class of ready-mixed paints which can not be too seriously condemned. They may be all right for the cow shed or chicken house, but they are not fit to put on a good dwelling. Competition has forced down the price until the manufacturers simply can not afford to use even fairly good materials. There may be many excellent ready-mixed paints, but the very cheap grades are practically worthless. It is the poorest kind of economy to slight this part of house building or to use inferior materials.

The colors may be bought dry or ground in oil, and absolutely pure linseed oil should be used for mixing. The labor of applying will be no greater; the paint will go farther and last infinitely longer than where cheap adulterated paints are used.

The first or priming coat should be mixed very thin. A cheap ocher will answer every purpose for color and body. It should be worked well in and brushed out, as the painters put it, and allowed to dry thoroughly. The sooner it can be applied after the siding is in place the better. The second coat should be somewhat thicker, of the proper color, and smoothly laid on. The third coat should be still thicker, and should not be put on until the second coat is thoroughly dry and hard. In fact, it is best to wait six months before applying the final coat. If any cracks or checks have occurred it will fill them, or they may be puttied, and if the materials have been of the best it will almost enamel the wood and leave it in a condition to withstand all kinds of weather for years.

As to colors, light tints should always be chosen for country dwellings. The smoke and dirt which render them impractical, or at least expensive to maintain, in the city are not present in the country, and they give a house surrounded by green (as the farm home should be) a brighter, cheerier, and cleaner appearance. A delicate pearl with lighter trimmings gives a durable covering and a neat combination. At all events avoid many and brilliant colors. Bright blues, pinks, yellows, etc., are indicative of bad taste, and soon tire even those who first advocated them. The custom, also, of combining a variety of colors—the house mainly of one color with a pink gable and a yellow foundation and similar abominations—are to be severely condemned. A light blue makes a pretty veranda ceiling, and there its usefulness ends for house painting.

The interior of a house should be almost free from paint. The kitchen floor, walls, and ceiling and the bathroom walls are the only places where it should be found. The woodwork should be sand-papered, and one coat of filler and one of hard oil applied.

The Heating and Lighting of the Farmhouse.—The question of how the farm dwelling should be heated will depend largely upon local conditions and the character of fuel to be used. Formerly our country dwellings were heated almost universally by means of stoves or, going still farther back, by open fireplaces. In the present day the open fireplace is a desirable feature of the library or general living room, but is not of great economic value as a means of heating except in southern climates.

In many of our farmhouses may be found modern heating appliances, consisting of either a hot-air furnace or a steam or hot-water equipment. Suitable heaters are now upon the market designed for the use of almost every kind of fuel.

The installation of heating appliances of an improved type is one of the most expensive features of home improvement. The cost of such installation will be approximately $50 for each room so heated. In some cases the work may be done for considerably less, but it is always well to figure on the highest price.

Furnaces appear to be gaining favor for warming houses of moderate size. If a good furnace of sufficient size is properly located and well put up there will be no cause for complaint. The hot-air pipes should be as short as the location of the registers will permit. The registers of the lower floor are often placed in the floor for convenience in piping, but the wall register is the best and should be used wherever possible. The cold-air pipe should be amply large and provided with a damper near the cold-air window. This cold-air connection to the furnace should always be directly at the rear. The advantage of the furnace system of heating is its direct supply of fresh air. A combination hot-air and hot-water system which furnishes warm air to a number of rooms and direct radiators to others is very efficient, but more expensive.

A hot-water system is similar in construction and operation to one designed for steam. It is regarded by many persons as the best method for heating residences. The water rises from the heater in the cellar to the radiators and is returned to the base of the heater, the change of temperature causing the circulation. The two-pipe system is more economical of fuel, but more expensive to install than the overhead system.

During recent years various forms of apparatus for lighting country homes have been devised. Kerosene has certain advantages, but the labor of caring for lamps is considerable. In all cases where lamps are used those of brass or similar metal should be selected in preference to glass. Metal lamps are safer than glass and are also more easily cleaned and handled.

Acetylene gas is now used quite extensively for the lighting of farmhouses. The installation of an acetylene outfit is rather too expensive for the average farm home, the generator costing from $125 to $250, in addition to the piping and lighting fixtures. This would bring the entire expense to approximately $300 for a seven or eight room dwelling. After the installation is effected, however, the cost of maintaining a plant of this nature is not great.

A number of manufacturers of electrical appliances are now producing small equipments for use in country places. These outfits consist of a generator which will furnish sufficient current for twenty-five or thirty 16-candlepower lamps, together with a controlling board and the necessary equipment for the installation. The cost of an electric lighting plant of this nature, exclusive of the engine, will be about equal to that of an acetylene gas plant. Provision is generally made for running the generator with the regular power provided for pumping water and doing other work upon the farm.

Water Supply.—Whatever the source of supply—a spring, a well, a cistern, or a running brook—considerable labor will be saved by providing economical means of lifting the water and delivering it where required for use. If a strong spring is available with plenty of fall below it, the water may be forced to the house by means of a hydraulic ram. The ram is the simplest of water-elevating devices, and the cost of operating it is practically nothing, as the waste from the spring acts as a source of power for the delivery of a small, but constant, stream of water to the house. A ram will give good service wherever the flow of the spring is upward of 5 gallons a minute, with a fall of 8 or 10 feet within 45 or 50 feet below the spring. The water may be raised to a height of 60 or 75 feet above the spring, but not more than 6 or 8 per cent of the flow will be delivered to the house. However, this is generally sufficient for all domestic purposes.

A very simple and satisfactory device consists of a high-grade hand pump in the kitchen with a suction pipe leading to the bottom of the well or spring. Water can be drawn a distance of 400 or 500 feet, provided the perpendicular rise is not more than 10 or 12 feet. Water can be lifted by a suction pump to a height of about 30 feet, but 25 feet is practically the limit for best results. For each 25 feet of suction pipe when bringing water from a distance an allowance of 1 foot less rise should be made. With a long suction pipe there should be a first-class foot valve on the end in the well or spring to prevent the water in the pipe working back when the pump is not in use.

Many sources of power for the pumping of water are available, such as windmills, hot-air engines, and oil or gasoline engines. Steam power is, as a rule, not adapted to the pumping of water on the farm, but with the increase in the number and efficiency of gasoline outfits it is a simple matter to provide for lifting water to a tank or delivering it direct to a house. There are small pumping engines on the market that can be had for $60 to $75, and which are arranged so that they may be bolted direct to the standard of an ordinary force pump.

Disposal of Sewage and Garbage.—The disposal of sewage has been a perplexing problem in the modern farmhouse. Three systems are in use. The ground available on one farm can not be, and need not be, exactly the same as that used on another. If the surface is almost level and under cultivation the subsurface system of distribution could be adopted, whatever the method used for collecting the flow from the house. The liquids are retained for a certain length of time and then rapidly discharged into open-jointed tiles, laid near the surface, thus securing a uniform distribution throughout the entire length of the drain. While the tank is refilling time enough is allowed for the water to pass away and the air to enter and accomplish its work. This manner of purifying the liquid wastes of the household where the water-closet is or is not used has been tried with entire satisfaction.

Another method of getting the liquid wastes on the land is by surface irrigation. The most marked feature of the change from the privy to the water carriage system is the great dilution which the organic matter undergoes. Instead of concentrated organic wastes, unsuited for direct use as a fertilizer, we now have a dilute mixture which seldom contains more than 1 part in 500 of anything but water. Of course this can not be discharged in a haphazard manner upon the land, but if the discharge be regulated to avoid saturation of the ground, the sewage can be disposed of without unsightly or offensive results. The area of the ground required is about the same as for subsurface disposal. A sloping surface in grass, or partially wooded, or a cultivated field, say of corn, would be entirely suitable. The area required depends upon the character of the soil and the amount of sewage to be purified. For a family of five, if the soil be reasonably porous, a plat of ground 40 feet by 50 feet should be ample.

The third method of exposing the liquid wastes to the action of the bacteria is used when the available area of the land is limited or if on account of the character of the soil too large an amount of drains would be necessary to handle the sewage to be purified. Under these conditions specially prepared beds of sand, gravel, or screened cinders are used as a filter material. The sizes of these beds vary with the amount and character of the sewage and its previous treatment, but for a family of five under reasonable conditions and a proper preliminary treatment, a bed 25 feet long, 4 feet wide and 4 feet deep should answer, although one 5 feet deep would give a purer effluent.

It is the regular taking care of the little things that advances housekeeping to a fine art. The more promptly and regularly all refuse of the household is harmlessly disposed of the better for the healthfulness and comfort of the home. If the ashes are kept free from organic wastes they can be used to advantage on the garden walks or to fill up low places. When taken from the stove or furnace they should never be stored in wooden boxes or barrels or in a fixed ash pit, but in a galvanized can, not too large to be easily emptied, that is fitted with a tight lid. Many serious fires have been started from the inexcusable carelessness of using a wooden receptacle for ashes.

The kitchen refuse from the preparation of the food can be saved for the pigs and chickens. It should be collected in galvanized-iron pails furnished with tightly closing covers to prevent exposure to the sun and to avoid flies. These pails should be washed and scalded each time they are emptied, and once a week, especially in summer, they should be rinsed with carbolic acid—a teaspoonful to a pint of water. Whatever can not be used in this way should be dried and burned.

Things that the junk peddler will take (old tin, iron, leather, rubber, etc.) should be cleaned and stored in sacks in a dry outhouse to await his next visit. No damp or decaying rubbish should be left in dark or out-of-the-way places.

Decoration of the Home.—It is not enough that houses merely be built; after they are built they should be made homelike by means of serviceable furniture and purposeful decoration. The taste and knack of the housewife may make even the commonest home attractive and restful.

All women cannot be artists. They may have dropped the brush and pencil when they began keeping house, but every day they make a picture; they try to bring their rooms and their furnishings into one harmonious effect. It is a great study, bringing zest to the daily work, and adding comfort and refinement to the home. There are principles in decoration that every one can learn; and good results will follow as the housewife studies nature in order to enable her to simplify and elevate her taste and ambitions.

Decoration is not mere ornament. It contributes to the making of a home picture. To produce a picture, the artist places on canvas the form and color necessary to bring all things into beautiful harmony. In the art of decoration we are constantly producing pictures. The decorator makes use of materials to produce effects, as truly as does the painter, but in a different way. The artist with brush works upon canvas not merely to show certain paints. The one who adorns her home, works for general effects, although attention may be centered on some particular object which is emphasized by a pleasing relation to its surroundings.

Comfort and good taste are excellent motives in decoration. The first law of good taste is simplicity. Two kinds of flowers do not grow on the same stem, although we are sometimes guilty of placing a conglomerate mixture of flowers in one vase. The Japanese teach us lessons in simplicity of decoration; their suggestions should do away with complex mingling of materials and arrangements. They do not display articles on their walls for mere ornament, but place them in cabinets to show to their friends as a matter of interest. Their homes are not overdecorated in order to show off bric-a-brac.

In seeking materials with which to decorate, combine utility and beauty if possible. This makes the most attractive decoration. As far as possible, avoid objects that catch dust and that need constant attention. Modern sanitary home-making avoids dust lines. Such dust-collectors as picture moldings on the walls, deeply grooved and filigreed picture frames, and heavily tasseled thick draperies make much extra work and are unsanitary. Dust is one of the friends of disease.

If carpets are used it is well to relieve a plain carpet by mats or small rugs in which are pleasing figures and colors. In selecting a carpet study to secure a design that will produce restfulness as the eye dwells on it. The size of the room may determine the size of the figure of the carpet. A large figure is obtrusive in a small room. Wide and pronounced borders may be successfully used in a large room, thus leaving smaller space to admit small designs or plain surface. The color of the carpet should be chosen with reference to the tone of the walls. The colors may be in strong contrast and still be pleasing. Brownish green is safe for it has a kindly relationship with other colors.

Paper is the expedient oftenest resorted to with which to cover walls. Bric-a-brac and draperies may be removed and replaced at will, but the wall paper must last through more than one season, a constant object for the eye to rest upon. The ingrain papers have proved a blessing in the way of wall decoration, since they have a plain surface, and, lacking the presence of conflicting figures, are a good background for pictures. Glaring designs and violent colors are to be avoided. Styles in wall papers should not necessarily guide the purchaser. Certain rooms, because of a small amount of light, demand light-colored paper, while a well-lighted room will admit of darker shades. A room in light colors always appears larger than one papered in dark colors. White is too glaring if used freely, although it may produce a light effect in a room. Cream or light yellow is more desirable, for when it reflects the light it gives a warmer glow than white. Deep yellow, deep blue, or heavy drab often lack delicacy and usually are inharmonious with all else in a room. Vertical stripes in the paper seem to add height to the room, while bringing the paper down to the picture molding about two feet from the ceiling gives the room a lower appearance. Large figures in wall paper, as in carpets, are suited only to a large room; while small figures suit the eye better in a room in which one wants the shut-in, cosy feeling, as in the small family sitting-room or in the bedrooms.

To complete the beauty of the home a careful selection of furniture must be made. Rooms should not be crowded, and furniture should be suited to the place it is to occupy. It is difficult to secure this fitness in detached articles. The articles may be good in themselves, but not appropriate to the place where they are to be used. We are too prone to regard a piece of furniture for the beauty in itself as it is seen in the store, without regard to its setting. In buying we must think of what we already have in order to determine whether the coveted object will be regarded kindly by its surroundings.

In some houses, the sitting-room concentrates the family life within itself, and is also the place where friends are received. In this case art and utility may combine gracefully—the art which pleases the eye of the visitor and the utility which provides the comfort so desirable for the every-day life of the family. This will place the flower-pot in the window, or a pretty shade on a lamp.

The necessity of making rooms comfortable and at the same time attractive and interesting, is an important study in the home.

To most persons the most attractive room in the house is the one with easy chairs; a table with good light, and which, if not well polished, may be tastily covered with a spread that harmonizes with the colors of the walls and rug; books, papers and magazines which indicates frequent use; a few pictures that are uplifting in the lives of the home folks; a corner in which to rest on soft cushions; and family life held together and sweetened by these refining influences. Such a cosy spot encourages the woman of the household to don a becoming gown, and to keep herself looking attractive and a real ornament in the home.

Pictures are not for the purpose of contributing to bodily comfort, nor for real utility. They are modes of expressing the thoughts and tastes of the dwellers in the home. They should be chosen because they mean something which one would wish to express, and because they are really beautiful. Their influence on character and on the beauty of the home counts more than all other decorative furnishings.

When pictures are chosen with this in view, little else is needed by way of decoration. Few can afford original masterpieces, yet we do not desire pictures which are less than masterpieces. Reproductions of excellent pictures, to be had in color and in black and white, may be purchased at reasonable prices. These may be chosen with a view to the place they are to occupy, not only on the walls but in the home life. Children like pictures of animals, of flowers, of birds, of scenes in which sunshine and action figure, while pictures of ruins and those which portray sorrow and suffering do not leave a good impression. Good photographs and prints of attractive farm scenes are always useful and appropriate in rural homes. They educate the taste to the beauty in one's own community.

To a great extent pictures take the place of bric-a-brac—the various fads in home decoration for which hands have worked for hours, and money has been saved for weeks. It is safe to say that the picture of a beautiful Madonna or other excellent subject, which may have cost little, has done more in a home to elevate the character and the taste of the individuals than all the worked cardboard, the embroidered lambrequins, and the many fantastic objects which are often collected and treasured.—(Consulted above and used in parts. Y. B. 1909; F. B. 270; Mich. Col. B. 250; F. B. 317; Of. Ex. Sta. F. Inst. Lec. 8; F. B. 126; Cornell Reading Course No. 2; F. B. 342; Cornell Reading Course 28, 29; Kans. Ag. Col. B. 143.)

THE BARN.*

Next in importance among the farm buildings, after the home of the family, is the barn. It should be so located that ready access from it to all the fields of the farm can be had, and yet near enough the residence that no extra steps will be needed in going to and from. Three prime requisites should never be lost sight of in building a barn: (1) The comfort and health of the live stock;

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* For illustrations, see pages 69, 159.

(2) its convenient arrangement to save time and labor in caring for the stock; (3) cleanliness.

The barn should be reasonably warm in winter and cool in the summer. It should have plenty of light and ventilation. Especially is good ventilation necessary in the cattle barn.

A sanitary and conveniently arranged barn costs but little more than one unsuited to animal life. The conditions governing the planning are very similar to those for a house, i. e., fresh air, sunlight, good drainage, and protection against sudden changes of temperature. The winter ventilation can be provided for by one or more flues so arranged as to allow the foul air to enter them near the floor line and to pass out through ventilators on the roof, the fresh air coming in near the ceiling.

Within the last few years a number of very sanitary barns have been built of reinforced concrete. This material is proof against fire, water, and vermin, needs no painting, little repairing, and is cool in summer and warm in winter.

The importance of thorough drainage should not be overlooked. This should extend both to the barn and the barn-lot. On the average American farm economy of construction and convenience require that provisions be made in the same building for horses and cattle. Directions given below furnish a very simple and convenient plan for a modern barn for mixed husbandry.

The first floor should provide for 4 horse stalls and 3 double cow stalls, while a shed with side open and intended to open into a small yard affords additional room for stock. A clear space, 12 by 37 feet should be left down the center, which will accommodate several vehicles and implements and leave room for a considerable amount of forage at the rear end. The loft will accommodate, if well mowed away, from 20 to 25 tons of hay. The granary should be 7½ by 8½ feet. In many instances this could be profitably cut down. The whole interior arrangement of the barn is intended to be merely suggestive.

Where the intention is to feed cattle or sheep the shed idea can be carried further and the entire left side of the barn be left unsided, affording a shed 37 by 11 feet with feed racks along the inner side, which may be conveniently filled from the center space or loft as desired. In a word, this barn affords abundant room at small cost and is capable of an innumerable variety of interior arrangements.

Light.—Sunlight is one of the most important factors in the stable management of live stock, especially for young growing animals and breeding stocks. A generous supply of it is needed in the cow stable for the maintenance of proper sanitary conditions and the good health of the animals. Dairy barns are seldom furnished with sufficient light; in fact, in the great majority of cases it is sadly lacking. Thousands of barns, especially of the basement type, have but few small windows, located close up against the ceiling, so that sunlight cannot reach but a very small area within the building, and that only near the center.

While sunlight is of great importance the comfort of the stock requires that during certain seasons of the year, when flies and other insects are troublesome, the windows should be screened or darkened by curtains. This is too often neglected and animals are left to the torture of the insects. Flies are unsanitary and it is especially important that they be excluded from dairy barns, as the torture inflicted by flies very appreciably checks the flow of milk. This is so well understood in some European countries that dairymen blanket their cattle while on pasture.

Ventilation.—What is known as the King system of ventilation is being used extensively in modern barns. The King system consists of two sets of flues. One set provides the fresh air, while the other furnishes an escape for the vitiated air. The inlet or fresh air flues should be placed not more than ten feet apart and located in the exterior walls of the barn; the greater the number the more effective the ventilation, since they enable the fresh air to displace the foul air more rapidly. The outlet may include one or more flues, but should be so located as to provide the quickest means of removing the foul air.

The ventilating flues should be so arranged that the cold air may be excluded in the winter and yet the foul air be removed.

Stable walls and ceilings should be practically air tight and non-conductors of heat and cold. Doors and windows should fit well. Fresh air intakes should have the outside opening at least 3 feet below the inside opening, with the inside opening at the ceiling, provided with a valve or shutter. Foul air flues should be air tight and non-conductors of heat and cold. They should have their lower opening about one foot above the floor level, and with as few bends as possible pass upward to a height of at least 25 feet, and should always be 2 or 3 feet above the ridge of the roof or of any nearby roof. In building these flues around a girt or plate they must be enlarged in proportion to the size of the obstruction passed.

In the arrangement the sunniest, warmest corner should be apportioned to the milch cows. The winter sun will prove a grateful tonic to them, and protection from severe cold or wintry blasts will prove a valuable assistance and money saver. Many dairy farmers build their stable walls double with chaff between, but such walls have several serious disadvantages. Inflammability is not the least; infection by vermin, disease germs, and the difficulty of disinfection in the case of the latter, all operate against such walls, warm though they may be. Double boarding, with a good quality of building paper between, and all cracks carefully battened on the outside, will prove much more advantageous. Above the stable single boarding with cracks well battened will prove all-sufficient.

The Floors.—Undoubtedly the most convenient floor for a stable is of cement. The ideal floor is made of cement with movable plank floors for the stalls. In localities where the soil is of a clayey nature the natural soil will make a very satisfactory floor if the stalls are floored with plank and plank gutters are provided for the manure. Such a floor makes an excellent temporary arrangement, and cement can be purchased and laid as time and funds will permit.

When hay, etc., is to be stored above the stock, as is very frequently the case, a tight second floor of matched lumber should be provided to prevent seeds and chaff from sifting down, and in any event such a floor will go a long way toward conserving warmth in the stable.

Some of the criticisms made against concrete floors are not well founded. Sometimes it is claimed they are too slippery and as a result animals fall and receive serious injury. It is true that this frequently happens, but it is due to improper construction; a floor given a smooth finish with a trowel is positively dangerous; it should be left to harden with a rough finish, such as that produced by the vigorous use of a steel broom. Alleys over which animals pass are rendered additionally dangerous by giving them more slope toward the gutters than is necessary. Strong claims have been made to the effect that concrete does not make a good stall bottom, producing rheumatism and other ills among dairy cows; this may be true if too little bedding is used and the animal is forced to lie on the concrete. Wooden floors are unsanitary besides being objectionable in other respects. They cannot be so readily cleaned, and cleanliness is an important factor in the care of stock.

Conveniences.—The tendency of the age is toward a conservation of time and labor in all farm work. This consideration should enter largely into the construction of the modern barn. The feed bins and chutes should be located so as to save as much time as possible in cutting up and in distributing the feed to the stock. Much wastage of grain may be avoided through this means. Chutes for hay and for straw for bedding should be located conveniently to the mangers and stalls. The hay chutes should be so planned that hay can be gotten from the mow to the first floor and into the mangers without filling the air with dust, and without littering the floor of the feed alley with dirt, leaves, etc. Canvas chutes for conveying bedding from the mow to the first floor will be found convenient. They can be folded and hung back out of the way when not in use.

Cupboards for harness should be provided, convenient to the stalls. Such cupboards will prove economical through preserving the harness and in saving time.

Where possible water should be delivered directly to the barn both for the use of stock and washing vehicles, as well as for flushing the floors. The floors should be so laid as to be readily flushed, and drainage provided for carrying off the water. The barn lot should be kept as dry as possible.

Manure conservation is another important feature of the modern barn. When it can be done it is best to have the manure hauled directly from the barn to the ground and there distributed so that nothing may be lost by leaching. When this cannot be done, to avoid unsightly and unsanitary manure heaps, a septic tank should be constructed. This can be done at small cost.

A work room for the repair of harness and farm implements should be provided either in the barn or in a separate building. The barn can be so constructed as to furnish room for housing the farm machinery.

Bank Barns.—In many situations the ground will be found to adapt itself to the building of a bank barn, and, although there have been many objections raised against this style of barn, the objectionable features can be provided against, and when the lay of the land lends itself to such a structure none more convenient nor comfortable can be adopted.

The chief objection to the bank barn lies in the fact that it necessitates a basement stable, one that it is claimed will prove dark, damp, and generally unhealthful. But these conditions are by no means essential. The ideal situation is a hillside sloping to the south. In such a situation the rising land to the north and the fact that the north wall is below the surface both serve to protect the stabling from the cold. The southern exposure of the stable, which should be provided with ample doors, admits an abundance of sunshine; and if low windows, such as are commonly known as cellar sash, be placed just below the ceiling on each side, they will afford satisfactory means of lighting and ventilating. In storing forage teams can be driven in on the main floor without climbing a steep ascent and hay and fodder put away on the same floor and with a minimum of labor. In too many instances the basements of bank and other basement barns have been placed too deep in the ground, and when so placed all the objections advanced against them are well sustained. The basement should be so placed as to permit of side windows at least two-thirds of the way back.

In building bank barns it is usual to construct the portion of the walls below the surface of stone or brick, but wooden walls coated with hot tar with tarred felt nailed over that have proved extremely durable.

Sheep Barns.—Where a large number of sheep are kept a specially designed barn is necessary. There is a very decided objection to a sheep barn with pens on both sides of a certain alley, because of the draughts that are sure to prevail. It is desirable to give the animals on both sides of the building access to the yards daily; if the pen doors on both sides are open at once there will nearly always be more or less draught, no matter how still the air may be and these influences are likely to result in prevalent colds and catarrh. Few sheep barns are so located that the pens can be opened up on one side or the other according to the direction of the wind, but if this arrangement cannot be made we would prefer a barn opening on one side only, to one with pens on both sides of a central alley.—(Mich. Col. B. 250; F. B. 126; Of. Ex. Sta. F. I. Lec. 8; Univ. of Wis. B. 164; F. B. 372; F. B. 190; Cornell Reading Course 30.)

*Dairy Barn.**—Dairying has grown to be so important a part of agricultural industry that much thought and study is required in planting a dairy barn. No two locations will require or permit of the same treatment so far as exposure, size, form or building material are considered, but the problems of ventilation, cubic air space per cow, light, floors, ceiling, etc., are nearly alike in all cases.

The building in which the milk is handled should be entirely separate from the one in which the cows are kept, as great cleanliness is essential in the handling of milk and other dairy products, nothing absorbing impurities more readily. The building should be well ventilated and so constructed as not to be readily affected by changes in temperature. The windows should be so arranged that the sunshine may be freely admitted at least once a day. Provision should be made on the ground floor for cooling the milk rapidly and for the separator and churn, the cellar being used for refrigeration and storage. The floors and walls should be of tile or composite material, so that a hose may be turned upon them and all thoroughly cleaned. The cellar walls may be faced with enameled brick.

An ideal plan for a barn which has been designed for 24 cows, allows ample room for calf pen and box stalls for bulls and cows, also space for feed room, hay chute, wash room and silo. The space allowed for the various purposes will meet the usual requirements. The arrangement of the space can be adapted to the needs of the particular location.

The width of this barn is 36 feet 4 inches outside. This allows ample room for the stalls and passageways, and permits of the most economical use of lumber in building. While the length of the barn is 84 feet 9 inches, this depends on the number of cows to be handled. The side walls are built of stone or concrete up to the window sills, the balance of the walls being frame. The end walls are constructed of stone or concrete up to the ceiling. A partition extends across the barn so that the cow stable can be entirely shut off from the rest of the barn.

Posts and Joists.—The posts carrying the upper floors are 6 by 6 inches, the girders 10 by 12, and the joists 2 by 12. If yellow pine is used, the joists should be spread 24 inches between centers but if hemlock is used, the distance should be reduced to 16 inches.

Windows.—One of the weakest points in barn construction is the small amount of window space usually allowed. The plan provides approximately 6 square feet for each cow. The windows are sliding sash extending to the ceiling, making them nearly twice as high as they are wide. This arrangement will admit much more light than the same space if the windows were placed otherwise.

Stalls.—The plan shows a width of stall of 3 feet 6 inches, which is as narrow as should be allowed. The depth is indicated as 4 feet 6 inches, but this may be varied according to the size of the cows in the herd. The manure gutter is 14 inches wide and 6 inches deep.

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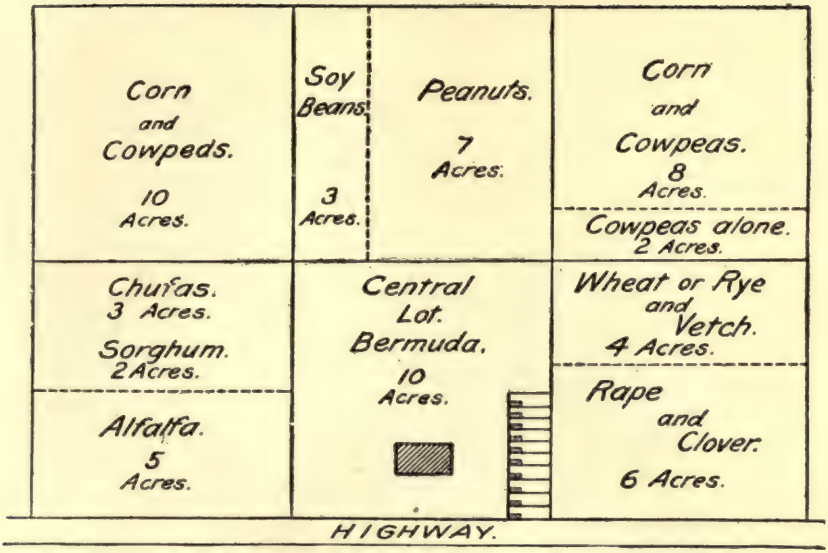
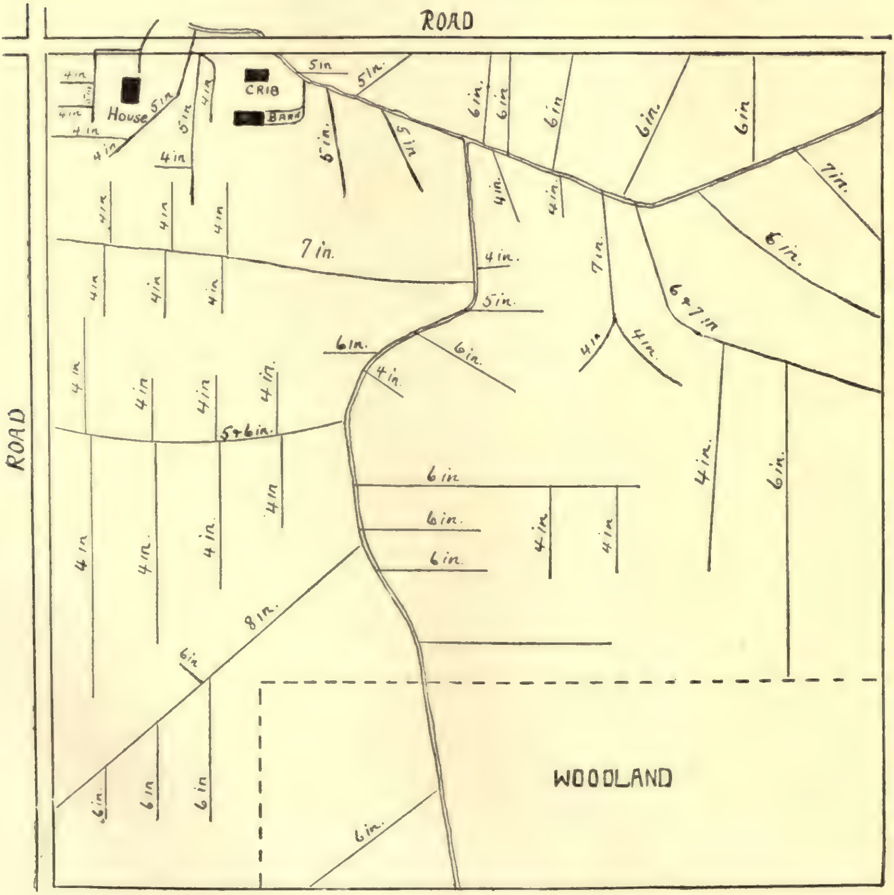
* For illustrations, see pages 447, 483.


Corn and Cowpeas. 10 Acres.
Soy Beans 3 Acres.
Peanuts. 7 Acres.
Corn and Cowpeas. 8 Acres.
Cowpeas alone. 2 Acres.
Chufas. 3 Acres.
Sorghum. 2 Acres.
Alfalfa. 5 Acres.
Central Lot. Bermuda. 10 Acres.
Wheat or Rye and Vetch. 4 Acres.
Rape and Clover. 6 Acres.
HIGHWAY.

A Plan of Rotation. Dept. of Agr. (See page 201.)



A System of Drainage. Dept. of Agr.

(See pages

Manger.—The manger is planned to be 2 feet wide and 6 inches deep, with slightly rounded corners, the front sloping at an angle of 45 degrees and the bottom being 2 inches higher than the floor of the stalls.

Floor.—The entire floor is concrete, 6 inches in depth when finished, laid over at least 6 inches of cinders or broken rock. Concrete is considered the best material for a floor for several reasons: (1) It is the only material that is sanitary; (2) it is economical because of its durability; (3) when a reasonable amount of bedding is used it is comfortable to the animals and no bad effects result. The floor is intended to be raised about one foot above the level of the ground to insure drainage.

Alleys.—The alleys behind the cows are 4 feet wide. Manure should be taken away from the barn daily and deposited in a manure shed or on the field, and the alleys are designed with this in view. It is undesirable from the standpoint of construction and sanitation to have a manure pit under the stable.

Calf Pen.—A comfortable calf pen should be provided, effectively separated from the milking herd. Individual stanchions are provided for feeding calves grain and milk.

Bull Pen and Box Stalls.—These are approximately 10 by 10 feet. There is a full window in each stall, providing an abundance of light.

Feed Room.—This is centrally located; a chute from the silo enters it, also two grain chutes from the upper floor. A hay chute from the loft above deposits the hay in the feeding alley.

Wash Room.—No dairy barn is complete without a wash room for the milkers and barn attendants, and lockers for their clothes. This room should also contain a small boiler for providing hot water and steam, as this is a necessary part of the equipment of a modern dairy barn. Milk scales, record sheets, milk stools, etc., may also be kept there when they are not in use.

Watering.—Watering devices may be put in the stable or provided for outside at the option of the builder.

Silo.—The silo planned for this barn is 14 feet in diameter and 32 feet high, and has a capacity of about 110 tons. This will provide silage for 24 animals for six to eight months.

Storage of Feed.—There is no objection to storage above the cow stable proper so long as the floor is of proper construction. It must be kept perfectly tight.

Ceiling.—In colder climates it is deemed better to have a comparatively low ceiling on account of temperature, but the construction admits of changes in this respect to suit the locality.

Ventilation.—The plan adapts itself to any system of ventilation. There must be openings where the fresh air may be taken in and the impure air discharged, avoiding drafts.

Driveway to Second Floor.—This is located on one side of the barn, at the end. The main reason for locating the driveway at this point is because it does not shut out any light from the floor below.

Stalls.—The market offers large numbers of patented stalls and mangers and devices for tying cows and other classes of cattle. There are strong arguments favoring metal stall fittings, and doing away with as much of the wood used as possible, in order to secure good sanitary conditions. At the same time, however, there are many people unable to purchase expensive fittings who are able themselves to build those made of wood. In general it should be borne in mind that the width and length of any stall is largely dependent on the size of the animal and the kind of manger and tie used. It is a common error to give a stall too much fall. In general two inches in ten feet should be the maximum fall for a stall of any kind. The distance from manger to drop for a 1,300 pound cow should be about five feet eight inches and for a 700 pound cow about four feet six inches. The width of the stall for the larger cow should not be less than three and a half feet, and for the smaller, two and three-quarters to three feet will answer.

Form of Barn.—There is a difference of opinion as to the best shape for a dairy barn, some preferring the rectangular and others the circular. Considering that the barn on a dairy farm is used twice every day in the year, and that for six months each year the cows occupy it almost continuously, and that during this time a large amount of the labor of the firm is done inside the barn, it is evident that the question of its convenience is a vital one. The amount of time and strength wasted in useless labor in poorly arranged buildings is very great. People do not stop to consider the saving in a year or a lifetime by having the barn so conveniently arranged that there is a saving of only a few seconds on each task that has to be done two or three times every day.

The round barn has a special advantage in the work of distributing silage to the cows. The feeding commences at the chute where it is thrown down, and is continued around the circle, ending with the silage cart at the chute again, ready for the next feeding. The same thing is true in feeding hay and grain.

The disadvantages of the round dairy barn are, that it cannot be enlarged by building on as readily as can the rectangular form, but as the round barn may be built higher to the eaves than a rectangular barn 36 feet wide, provision can be made for the growth of the herd by building so as to put cows in the second story and still leave sufficient mow room for hay.

The objection is frequently raised that a round barn is difficult to light. This difficulty is entirely overcome in a barn 90 feet or less in diameter, if a sufficient number of properly spaced windows are used. With the same number of windows, the light is more evenly distributed in a round barn and the sun can shine directly into some portion at all hours of the day during the winter.

*The Dairy House.**—With the dairy barn necessarily is connected the dairy house for the care and handling of the milk.—(Uni. of Ill. B. 143; Bu. An. Ind. B. 131; Of. Ex. Sta. Lec. 8; F. B. 126; Cornell Reading Course 23.)

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* For illustrations, see pages 303, 411.

Ice Houses.—An ample supply of ice is of greater economic importance in the country home than in the city residence. City people can purchase perishable supplies as needed, but the remoteness of country homes from markets often renders it necessary to use canned, corned, or smoked meat products during the season of the year when the table should be supplied with fresh meats. Not only is ice appreciated because of its use in the preservation of fresh meats, butter, and other table supplies, but the production of high-grade domestic dairy products is almost impossible without it. Many markets to which milk is now shipped demand that it be cooled before shipment to a degree not attainable without the use of ice.

Ice is one of those luxuries which in many sections of the country can be had for the gathering. The cost of harvesting and storing it is not great as compared with the comfort that it brings.

The work of harvesting and storing is done at a season when it will cost very little, as help and teams are usually less remuneratively employed during the winter than during the summer months. The cost of constructing ice houses and refrigerators is small in comparison with the economic returns and in the comfort which they afford.

The storage of ice can be made profitable in many parts of the country by using it to keep milk and cream in better condition. Wherever the natural product can be secured the cost of storing is so small that no one need be without ice on this account.

On the basis of a 20-cow dairy it requires about 500 pounds of ice to cool the cream annually produced by one cow. To this amount should be added 500 pounds more for waste, or a total of 1,000 pounds a year for each cow. This amount is sufficient to keep the cream sweet and in good condition, so that for a herd of 20 cows 10 tons of ice would be required. In smaller dairies the waste would be greater and proportionately more ice would be required, while with larger ones a proportionately less amount would suffice.

The Building.—In building an ice house the main object is to secure isolation of the ice by surrounding it with an adequate amount of nonconducting material. The house should have double walls packed with sawdust, a drain at the bottom to carry off water without admitting air, and a ventilator at peak of roof to allow vapors to pass out. There should be no windows, and the door should be as nearly airtight as possible.

There are approximately 50 cubic feet of stored ice to the ton, consequently for 10 tons it would be necessary to fill a space 10 by 10 by 5 feet. An ice house for this quantity should be built 12 by 12 by 8 feet, which would allow for 12 inches of sawdust on the sides (sufficient to keep ice under ordinary conditions) and enough space on the top for packing and covering the ice.

In a small ice house there should be about 12 inches of sawdust between the ice and the walls of the house. Ample ventilation should be provided. The most efficient probably is an opening of a few inches under the eaves. This will allow free circulation of air, but will not permit the rays of the sun to shine on either the sawdust or the ice. The sawdust should be kept well packed on the sides and evenly distributed over the top surface of the ice. Sawdust will keep ice much better when dry than when wet.

Since ice at best is a very perishable product, requiring special equipment for its preservation, such natural advantages as are offered by shade and exposure should be taken advantage of in locating an ice house. A shady situation with a northern exposure has a decided advantage as a location for such a building.

In general design ice houses are of three types: (1) Those built entirely above ground; (2) those built partly above and partly under ground; and (3) those of the cellar type, built entirely below ground. The above ground structure is by far the most common of these types.

The advantages and disadvantages of these three types may be briefly stated as follows. Above ground houses can, as a rule, be more economically constructed than either of the other designs. Excavations are expensive to make and difficult to insulate and drain properly. Insulation and drainage are two of the most important factors in the preservation of ice. It is true that the temperature of the earth varies less than that of the air, but the fact that the temperature of the earth at 6 or 8 feet below the surface remains at or about 55° F. the year around makes it quite as important to protect the stored ice against the earth heat as against the heated air. It is more difficult to remove ice as needed during the season from pits than from structures above ground. Slight advantages are apparent at harvest time in favor of the cellar or the half-sunken types of house, and under some circumstances they will be preferred to the other type.

The length of time ice may be kept depends upon the character of insulation provided. This will naturally vary with the location of the ice house and the method of construction. The simplest type of ice preservation consists in stacking the cakes in a compact mass on a well drained site, as well protected as possible by natural or artificial barriers from sun and wind, and covering the mass with sawdust, shavings, fodder, marsh hay, or any other good insulating material. Such a crude method is not to be recommended except as a temporary makeshift for ice that is to be used early in the season.

In order that the house may be filled without unnecessary labor a continuous door should be provided in the middle of one end. The door should be made in two or three sections, and as the house is filled loose planks of proper length should be at hand to place across the opening of the door to hold the packing material in place as the heap of ice grows in height.

The ice must be placed on a bed of sawdust, shavings, or other packing material at least 15 inches deep, and the rick of ice should not approach the side walls closer than 15 or 18 inches, the intervening space being filled with packing material and thoroughly rammed.

Instead of the cheap, temporary construction just described, ice houses of a permanent nature can be built from brick, stone, or concrete. In these, as in frame-constructed houses, the mass of ice should approach as closely as possible a cube in form. If the masonry house is to be used in the same manner as the temporary house no inside lining will be necessary. The packing used about the mass of ice may be allowed to come in direct contact with the wall. A 13-inch brick wall or a 12-inch concrete wall will provide the necessary strength. The masonry walls are not as good nonconductors as timber walls. It will therefore be necessary for the protection of the ice to rely on the packing material rather than on the wall itself.

Harvesting the Ice.—The source of the ice supply will vary with local conditions. In many sections lakes, rivers, or large streams will afford a supply of suitable ice without special plan or preparation on the part of man. In other instances, where such natural sources are not easily accessible, small streams or even the water from a spring can be stored in an excavation or by means of a dam, so as to afford sufficient water surface to provide the desired ice supply. The harvest area or surface will depend upon the tonnage to be stored and the normal thickness of the ice in the locality.

The stream or pond from which the supply of ice is taken should be fed from a source free from contamination or pollution. If the stream is so sluggish that water weeds thrive in it, all vegetation must be removed to prevent its freezing in the ice. Decaying vegetable matter frozen in the ice is very objectionable, because as the ice melts this matter is deposited in the ice box or refrigerator, rendering it unnecessarily filthy and dangerous to health.

Ponds in which green spawn or algæ grow profusely can be rid of these pests by the use of copper sulphate. The crystals can be placed in a cloth sack, which is hung to a pole and trailed through the water until the salts are dissolved. One or two treatments of the sulphate during the season at the rate of 1 pound to 100,000 gallons of water will be sufficient to keep down such growth and make the water clear and pure. It is impossible to have pure ice unless the pond or stream is clean and the water is free from contamination.

The ice itself must be packed so as to prevent as completely as possible the circulation of air through the mass. The more nearly the mass of ice approaches that of a solid cube, both in shape and texture, the easier, with good drainage and insulation, will be the keeping problem. The keeping of ice depends upon the shape of the mass, its insulation, its drainage, and its solidity. The ease and rapidity with which ice can be gathered depend upon the condition and location of the field and the character of the tools and conveniences at hand for doing the work.

If the ice field is covered with snow the formation of ice will be retarded, as the snow acts as a blanket and raises the temperature, thus retarding the ice formation. If the ice sheet is sufficiently thick and snow falls upon it, the snow must be removed before harvesting can proceed; or if, on the other hand, it is desirable to increase the thickness of the ice after the snow falls, the field may be flooded and the snow saturated with water, which is allowed to freeze, thus adding a layer of snow ice. Flooding on small fields may be accomplished in either of two ways: (1) by overflowing, which consists merely in conducting water to the field, or by piercing the ice field here and there with a bar or auger, to allow the water to force itself to the surface and gradually to saturate the snow. Snow may be removed from small fields, when necessary, by means of shovels, but upon large fields it will be economical to use horse-power scrapers.

Under certain conditions the only practicable way of obtaining a supply of natural ice is to catch it as it is going out in the spring. When the snow melts and the spring rains come on the ice at the headwaters of streams breaks up and is carried down in large masses, which can be caught at considerable distances from the localities where it was formed. Those fortunate enough to live conveniently near large streams may often obtain their ice supply in this way.

Fruit Preservation.—In order that fruits may be held for long periods in storage it is necessary that a uniform low temperature be maintained in the store-room. With many products a uniform temperature is of more importance than a low temperature. With apples, which is the crop usually held in storage, it is desirable that the fruit reach an advanced state of maturity upon the tree, but that the ripening process be checked immediately when the fruit is placed in storage. This sudden check can not be effected in ordinary storage at picking time. It is therefore necessary that the storage house be provided with means for reducing the temperature to the required point and holding it there until natural conditions permit the introduction of cold air from the outside. Several systems have been used for accomplishing this result. The simplest is to build the ice house as a two-story structure and to store the ice above and the fruit below.

For the Dairy.—Even where for convenience and economy it is desirable to have the dairy under the same roof as the ice house, it is not satisfactory to attempt to combine the ice storage with a cold store. When it is necessary to use ice for chilling milk or other dairy products it is better to remove the ice from the ice house or compartment and place it in a specially constructed ice box or refrigerator rather than to attempt to maintain a cold room by storing the ice about and in contact with it. The chief argument against the combined arrangement is that it prevents the storage of ice in a solid mass. As a result the waste is much greater. Again, the requirements of the storage room and the refrigerator vary from time to time. Advantage can be taken of these fluctuations to husband the ice supply when the two are separate. There are decided advantages in having the ice supply convenient to the dairy house or refrigerator, but it is poor economy to build the refrigerator or cold store inside the ice storage.

Ice House and Refrigerator.—When an abundant supply of natural ice can be harvested annually it will be a simple matter to maintain high class refrigeration, for the preservation of eggs, fruit, meats, butter and other farm products, by installing a brine circulation system. The principle on which this system works is the same as mechanical refrigeration, except that the cold is secured through a freezing mixture of ice and salt in a tank in which the primary coils are located. As the brine in these coils becomes chilled it passes out through the bottom of the coils, which are located in the cooling room.

The space above the cooling room, if desired, might be utilized as a farm shop or for a cooperage if one were to be installed in connection with an apple orchard. It would not be advisable to attempt to install this system without having an experienced engineer calculate the piping necessary for any given storage room as well as the cooling tank. The question of installation is also a very important one and should be carefully specified.

Ice Chest.—Where a less expensive cooler is desired an ice chest will be found to serve a useful purpose. Such a chest can be made from two boxes, one 12 inches longer and wider than the other and 6 inches deeper. If the inner box is 2 feet wide, 2 feet deep, and 3 feet long, the outer box should be 3 feet wide, 4 feet long, and 30 inches deep. The inner box, which should be made of matched white pine or cypress, should be lined with zinc and provided with a drip pipe in the bottom near one end and a metal grating 12 inches from that end, so as to make a cage in which to store a block of ice. A layer of 6 inches of cork dust or dry white-pine shavings should be placed in the bottom of the larger box after it has been lined with waterproof building paper. Place the smaller box on the layer of insulation, making provision for the drain, and then pack the same insulating material tightly in the space between the outer and inner box. Fit a board over the packing between boxes so as to cover the edges of both. Then hinge a thick well-insulated cover to the outer box, which should fit tightly and be large enough to cover the entire top of the chest. The joints can be made tight by weather strips and felt. The cover should be provided with a counter weight and a good ice-chest hasp to hold it in place.—(Y. B. 1909; F. B. 126; Of. Ex. Sta. F. I. Lec. 8; F. B. 475.)

The Sanitary Privy.—The subject of farm buildings can hardly be considered closed without some reference to the subject of sanitation, particularly as it concerns the disposal of sewage.

The farmhouse which is supplied with abundant water, either running or so stored as to give a sufficient force, can easily be further provided with a flush-out water-closet and a sewer constructed of vitrified sewer pipe of sufficient length to carry sewage beyond the possibility of land or water contamination. But the farm dwelling with these advantages is, unfortunately, the exception rather than the rule, and therefore some other means for sewage disposal must be provided.

The most common form, and, when properly constructed, probably the cheapest and best, is the privy. As commonly constructed, with a vault of more or less depth, this useful contrivance is not only extremely obnoxious, but is a menace to health. The supposition that because the privy stands on slightly lower ground than the top of the well, and that because the well can not become infected by surface drainage there is no danger to be apprehended from the privy, is all too common. It is practically impossible to judge by the surface of the ground of the various strata of soil below, some of them capable of conveying sewage contamination several hundred feet. The very fact that the liquid in a privy vault seeps away is sufficient evidence that it has struck some porous strata and is going somewhere, and the frequent cases of typhoid and diphtheria on what should be thoroughly healthful farms are ample proof that it all too frequently finds its way to the source of drinking water. Another fact that should not be lost sight of is that wells are usually fed by underground courses, and one of these may pass directly beneath the privy vault.

The cleanest, safest, and in every way least objectionable privy is the form known as earth closet. In such an one a quantity of fine, dry earth is kept handy for constant use, while beneath is a receptacle for the excreta. Every time the privy is used a small quantity of earth is emptied into this receptacle, and at frequent intervals the night soil, made as little offensive as possible by the admixture of dry earth, is hauled away, to be applied to some portion of the farm where there can be no possible danger of infecting the water supply.

Where there is difficulty in the matter of ultimate disposal without the use of a cesspool, and the consequent and apparently unavoidable risk thereby incurred of contaminating the well water, it would be better to use an earth closet. This is not wholly satisfactory, but is safer and far better than the provision so often found on farms and in villages. The house containing it should be well built and substantial, well lighted and ventilated, with a good roof, and preferably plastered on the inside to insure less exposure in cold weather. A carefully made and dry walk, screened by lattice for protection from the wind and for privacy, should be built to it. The excreta should be received in a galvanized-iron pail, not too large and made to fit close under the seat. This seat can be like that of an ordinary water-closet. Each time the closet is used dry earth is added. The pail should be emptied very frequently. With proper attention this closet need not be, and should not be, built far from the house. It would even be possible to place it in a room built against the house, the room having one door opening from the house and another opening out of doors. This would make it possible to enter from the house in inclement weather, and also to carry out the pail without passing through the house. The room should be well ventilated by a window close to the ceiling, and only tissue paper should be used.

The earth for use in these places is to be found in nearly every field and garden and should be of rather a loamy nature if possible, and porous. A very sandy soil is next to useless. Large heaps of earth should be collected for the year's use and dried in the summer sun. It is not necessary to use perfectly dry earth, but it is always the best.—(F. B. 126; F. B. 463.)

Protection of Buildings.—The ordinary farm building is not difficult to protect from lightning flashes in the great majority of cases. While absolute protection can not be secured unless the building be incased in a network of wires, it is believed that a building with a properly installed system of lightning conductors will fare better than one without such a system in case a discharge of the most violent type should fall upon it.

Whether or not to install lightning conductors on one's property is a question, after all, of individual judgment. If the property is insured against loss by lightning there would be little incentive toward incurring additional expense for lightning conductors. In case of an isolated farm building standing apart from trees it would seem that the conservative course would be to erect an inexpensive system of lightning conductors.

An inexpensive yet effective lightning conductor can be erected by any one out of materials that can be purchased from the larger electric supply houses. No. 3 and No. 4 double galvanized iron telegraph wires make an excellent lightning conductor. While iron is not so good a conductor as copper, it is less likely to cause dangerous side flashes and it also dissipates the energy of the lightning flash more effectively than does the copper.

The conducting system is composed of a horizontal wire following the ridge of the roof and two vertical wires connecting with the ground on both sides of the building. The wires should be fastened to the building by galvanized iron staples about an inch long; they are not to be insulated from it as was once the practice. Another way to fasten the wire to the building is by means of small wooden blocks and screw eyes. Blocks 1½ inches thick, 2½ inches wide, and 4 inches long into which a stout screw eye is fastened may be nailed to the sides and the roof at intervals of 10 feet or less. The wire can be easily passed through these eyes from the ground to the top of the building.

The vertical wires should be connected to the horizontal wire by galvanized iron T's. The necessary T's should be slipped onto the horizontal wire and placed at points of junction with the downward directed wires, and also at such points as it is wished to erect short terminal rods along the ridge of the roof.

The end terminals are best formed by making a right angle bend in the wire which runs along the ridge of the roof at a distance of 20 inches from the respective ends. The middle terminal is merely a wire 20 inches in length held in place by a T connector. The terminals are short and offer little resistance to the wind; they are kept in a vertical position by the connections between the ridge wire and the wires leading to the ground.

The end of the upper terminal should not be left blunt, but should be filed down until it is cone shaped. Since the filing removes the galvanizing over the surface of the cone, the latter should be heavily coated with paint to preserve it from rust. In general a terminal rod should be erected every 18 or 20 feet along the ridge of the roof.

The number of terminal wires depends on the number of cupolas, chimneys, or other salient points on the roof liable to be struck. A short terminal wire connected to the main conducting wire by a T should be erected at each cupola or other salient point.

The earth connections require great care in their construction. The essential thing is to reach permanently moist earth in the shortest distance from the main conductors. Some buildings have two ground connections, one on each side of the building. The ground ends of the vertical conductors, or wires, should be coiled in a spiral having a diameter of about a foot. These spirals should be buried in moist earth.

Grounding of Fences.—Wire fences should be grounded every sixth post to protect live stock in the fields from lightning where it strikes and runs along the fence wires. The method is simple and inexpensive. All that is needed is to force a ¼-inch round pointed rod down along the post to make a hole, and then put down a piece of heavy galvanized wire, going down about thirty inches. The wire should be long enough to reach the top of the post, and should be fastened to the horizontal fence wires with staples.

In conclusion, a word should be said about watching the lightning conductor system. Like everything else, it is apt to get out of repair and, like everything eles, the sooner repaired the better. Do not allow the points to become bent, and see that the grounds and all connections are in good condition.—(F. B. 367; Manitoba Ag. Col. B. 4.)

SILOS AND THEIR CONSTRUCTION.*

The advantages which are obtained through the use of a silo for preserving coarse fodders for the feeding of farm animals may not be the same for each individual case; but the points enumerated herewith will probably hold in the majority of instances and cover average conditions.

1. The product of an acre of land can be stored in less space by making it into silage than by curing in any other way. Hay placed in the mow will take up about three times the space and corn fodder about five times the space as the same quantity of food materials placed in the silo.

2. An acre of corn can be placed in the silo at less cost than the same quantity can be put up as cured fodder. The usual method of cutting and shocking the crop, then husking, cribbing, shelling, grinding the grain, storing and shredding the fodder and then putting them together again is expensive and would seem to require much labor that might be obviated if the whole crop was secured at one time as is done in putting it in the silo. The storage of the corn crop in the silo makes it possible to clear the ground completely and earlier and thus facilitate the preparation of the land for seeding grass and fall grains.

3. The use of the silo makes it possible to preserve roughage so as to entail a minimum of loss of food and feeding value. It supplements the pastures at such times as they are short.

4. The use of silage enables the farmer to feed his animals more economically than by the use of dry roughage.

5. Crops can be secured in the silo during weather that could not be availed of to make hay or cure fodder.

6. More cattle can be kept on a given area of land when silage is fed than when the roughage is cured for hay or fodder, or when the land is used for pasture purposes.

See page 33 for illustration.

7. Crops unfit for making hay will often make a nutritious, palatable silage and thus enable the farmer to carry his stock during times when hay crops are a failure.

8. The use of silage enables the feeding of a succulent and uniform food the entire year. Silage is beneficial to digestion and general health of animals. It is a mild laxative and keeps the digestive system about in the same condition as when animals are on pasture or being fed with green fodders. The feeding of silage previous to turning animals out to pasture is beneficial and prevents the loss in weight which frequently occurs.

Every farmer who is interested in the feeding and maintenance of live stock should have a silo. Silage is not so satisfactory as a feed for horses as for beef and dairy cattle and sheep, but fed in conjunction with some other ration has been found to be beneficial to horses.

Size of Silo.—The size of the silo should be determined by the amount of stock to be fed and the length of the silage feeding season. In most sections the silage should be available from six to seven months. Silage is usually fed to cows and steers at the rate of 30 to 40 pounds per day. This would mean that in 200 days a cow would require from 3 to 4 tons of silage. These figures give a safe basis for calculating the requirements of a herd. The size of the silo should be such as to make it possible to feed daily from the whole surface of the silo to a depth of two inches; so as to prevent loss by undue exposure of the silage to the atmosphere and keep it in the best condition for feeding. Silage weighs from 30 to 50 pounds per cubic foot. Good corn silage averages about 35 to 40 pounds. Clover and cowpeas silage weigh more than corn silage. One acre of corn should yield from 10 to 15 tons of silage and one acre of clover, vetch, cowpeas, rye, etc., should yield from 8 to 10 tons of silage. Only circular silos are now being constructed, and the following table gives the approximate capacity of silos in tons. From these figures a farmer may easily plan his silo and the area of silage crops to meet his requirements:

Height of Silo.	INSIDE DIAMETER OF SILO—FEET.						
	10′	12′	14′	15′	16′	18′	20′
feet	*tons.*	*tons.*	*tons.*	*tons.*	*tons.*	*tons.*	*tons.*
20	26	38	51	59	67	85	105
21	28	40	55	63	72	91	112
22	30	43	59	67	77	97	120
23	32	46	62	72	82	103	128
24	34	49	66	76	87	110	135
25	36	52	70	81	90	116	143
26	38	55	74	85	97	123	152
27	40	58	78	90	103	130	160
28	42	61	83	95	108	137	169
29	45	64	88	100	114	144	178
30	47	68	93	105	119	151	187
31	49	70	96	110	125	158	195
32	51	73	101	115	131	166	205

Construction of Silos.—The first silos were mere pits in the ground, but these were abandoned principally because of the difficulty of feeding from them. The square or rectangular silos were found objectionable on account of the difficulty of filling the corners so as to exclude entirely the air. Silos are now universally circular in form, and are built out of staves, cement, concrete or brick. The round silo has two distinct advantages. First—There are no corners in which decay may develop. Second—The pressure is equally distributed from the center to each side, so that there is no unequal strain upon the walls or sides of the silo of this form, while the pressure from above on the silage below is uniformly distributed. These advantages have been found to be so distinct and important that at this time but comparatively few silos are built, excepting of the circular form.

Foundation.—On building a silo it is of the utmost importance to have a good foundation. It should extend below the frost line and should rest on hard ground. If the silo is built of brick, concrete, or stone, a more solid foundation is needed than if wood is used. In such a case it may be better to consult an experienced mason, as the condition of the ground where the silo is to be built may make considerable difference in its construction. Some builders simply dig a trench and build a wall in this up to a level with the surface. A better plan, however, is to excavate the dirt from 2 to 5 feet below the feeding floor of the barn and build a good wall, beginning at the bottom of this excavation. The capacity added to the silo will amply repay for the extra cost involved. The bottom of the excavation may be somewhat larger than the top, as the base of the foundation wall should be at least 24 inches thick, while it need not be more than 8 inches thick at the surface of the ground.

The practice of digging a trench and filling with concrete is not recommended unless the soil is firm and of such a nature that it can be finished up smoothly. A tar or building paper lining may be used to line the trenches in porous soils. It is difficult to plaster concrete which has come in contact with the soil. In extending a part of the silo below the surface, the soil should not be used as a part of the form. The concrete to be durable and economical should contain only clean and durable stone, gravel and sand. Brick foundations should only be of hard burned brick laid in cement mortar and when so built are considered satisfactory.

The foundation should have such an effective bearing surface as to prevent any appreciable settling. By effective bearing surface or area of footing is meant the area of that part of the wall and floor which in case of excessive pressure helps to carry the load placed on it. Fortunately, the weight of the silage is supported almost entirely by the floor and not by the foundation. The weight on the foundation is practically only that of the wall and roof. For a concrete silo under 50 feet in height, the width of footing need not be over twice or three times as wide as the thickness of the wall for any kind of soil except soft clay or quicksand.

Exclusion of Air.—The fundamental principle in the preservation of green forage when placed in a silo is to exclude air as far as possible from the silage and in this way prevent decay. To prevent the air from reaching the silage all silos must have air tight walls. These must be rigid enough not to be sprung out of shape by the pressure of the silage, permitting air to enter next to the wall. Not only the walls but the doors also, must be perfectly air tight. To accomplish this they should be well fitted and the joints made more perfect by felt pads or gaskets. It is good practice where the silo door sets against a shoulder, to place clay worked into the consistency of putty in the joint. The clay is placed on the bearing surface and the door placed over it, and when the pressure of the silage comes against the door an air tight joint is obtained. Tar paper is successfully used by some silo owners either in strips to cover the cracks around the doors, or in width sufficient to cover the entire door and lap a few inches on the silo walls.

Stave Silo.—It is probable that no better material can be obtained for the staves than Southern cypress. This, however, is so expensive in some localities as to preclude its use in most cases. Of the cheaper materials hemlock, white pine, and yellow pine are usually the most available. At the present time hemlock is one of the cheapest satisfactory materials which can be purchased and it is probably as good as any of the cheaper materials. It should be sound and free from loose knots. If the staves are left perfectly plain, then when they are set in place and drawn together the first point of contact will be the inner edge and the tighter the hoops are drawn the closer will become the contact of the staves at the inner edge. If it is impossible to purchase material for staves the length of which shall be equal to the desired depth of the silo then shorter staves may be used and set up. The staves should be surfaced on the inside so that a smooth face may be presented which will facilitate the settling of the silage. Whether the outside of the staves shall be planed is a matter of taste, but if hemlock is used the handling of the staves will be found much easier if both sides are planed. To prevent stave and wooden-hoop silos from becoming displaced from their foundations by high winds and to prevent creeping due to the swelling and shrinking of the wood, they should be anchored with three or four three-eighths inch rods or wire cables running from the eaves to the top of the foundation, or to anchors buried in the earth a few feet from the base of the wall. Rods with a hook or eye to which these stay rods or wires may be attached can readily be embedded in the masonry of the foundation. These stay wires can easily be made by stringing four No. 12 wires loosely from the eaves to the rods in the foundation and then twisting them into a taut cable with a short stick.

Concrete Silo.—The single wall concrete silo is the most common style of construction. The thickness of the walls of silos now in use varies from six inches at the bottom to four inches at the top for the lightest wall to a wall two feet in thickness. Six inches seems to be the most desirable thickness for common sizes of silos under existing practice.

Only a first-class Portland cement which has been stored in a perfectly dry place should be used. The proportions of cement and gravel will vary with different grades of gravel. If broken stone is available and cheap, it may be used with sand instead of gravel. To obtain the best grade of concrete the gravel and sand must be clean and durable and the cement must be in such a proportion as to nearly if not altogether fill the voids or open spaces between the sand and gravel. To obtain the strongest concrete with the minimum of cement the sizes of the gravel should be in the right proportion and vary from the largest to the smallest sand particles.

Gurler Silo.—One of the most successful types of silos is that generally known as the plastered or Gurler silo. This type is especially adapted where there is still a local supply of native lumber which furnishes a cheap building material. The Gurler silo is built much like a frame house, except that it is round in form, with a lining of boards running lengthwise around it, somewhat like the hoops of a barrel which give it strength to resist the immense pressure of the silage. Its cement plastered wall protects the wood framework from decay. Some of the strong points in favor of this style of silo are: (1) Can be built entirely from ordinary lumber; (2) requires no highly skilled labor for its construction; (3) preserves the silage as well as any type of silo in use; (4) is strong and durable when properly made.

Ventilation.—Carbon dioxide, a gas heavier than air, will collect above fresh silage if not given an opportunity to flow away to a lower point. This might be the case where the doors are not continuous and the gas is pocketed below a door. Care should be used in beginning work in a silo after it has been standing for a time partly filled with fresh silage. If silage is allowed to fall into the silo for a time, the carbon dioxide will be stirred up to such an extent that there will be no danger from asphyxiation. Although many silos are provided with ventilators, it is doubtful if they are of any practical value whatever. Under usual conditions, it is best to prevent circulation of air above the silage.

It is desirable to prevent the freezing of silage in the silo during cold weather as far as possible and the silo of a construction to prevent freezing to the largest degree is the preferable one, other things being equal. It is difficult to make a comparison between the merits of the various types of silos in this respect owing to the inability to find them under like conditions. Freezing of silage is due to loss of heat; first, through the silo wall; and second, to the air in contact with the feeding surface. The first loss may be reduced by using a non-conducting wall in the silo and the second by preventing the circulation of air above the silage in the silo.

It may be impartially said that, as far as the prevention of freezing of silage is concerned, the stave, stone, single wall brick and concrete silos are of about equal merit. Any kind of an air space will partially prevent freezing, depending upon how little the air circulates in this space and also upon how much conducting material is required to tie the outer and inner walls together. The King and Gurler silos were among the first to make use of an air space to prevent the loss of heat through the walls, but the air spaces were so deep that circulation of air from the top to the bottom of the wall was quite free and readily transmitted heat from wall to wall in this manner.

Location of the Silo.—This will depend largely on the character of stock to be fed. It is not always an advantage to build the silo on the inside of the barn. In a dairy barn it is better to have it on the outside, though joined directly to it. By keeping closed the door leading to the barn, the odor of the silage can be kept out of the stable and prevented from getting into the milk. It is as easy to distribute the silage by means of a car to two rows of cattle when located just outside the barn as when built in the corner of the barn. In a beef-cattle barn the odor would not count for anything, and if a large number of animals are to be fed it is well to locate the silo in the center of a shed-like structure, which can be utilized with economy in the winter feeding of beef cattle. The great advantage of building the silo outside the barn is due to the fact that the round silo is the preferable type to use. When one is building a barn it is a different problem, as a round silo can often be located in the center to advantage, whereas, after the barn is erected, it could not be built except with an unnecessary outlay of labor and expense. Unless the barn is a round one it is best to build the silo at one end of the barn. The silo may be made an ornament to any group of farm buildings. Its form is such that it may be made to add to the appearance of any style of construction. One or more conical silo roofs when viewed from a distance; or the full height of the curved walls at a closer range, gives a very pleasing effect when placed in a setting of rectangular buildings. This impression is entirely independent of the great value of silage as a feed and is pleasing to such a degree that a prospective purchaser, in making a close decision, would be influenced to a far greater extent than the original cost of the silo.

Filling the Silo.—For best results forage which is put into a silo should be cut fairly fine so that it will pack close and exclude the air as much as possible. This material can be conveyed into the silo by means of an elevator or conveyor. There are a few favored sections that can locate the silo so that it may be filled from the cutter by gravity. The silo may be filled with uncut forage, but this is not advisable if cutting machinery can be procured, as the silo will not hold as much and the material in its natural shape will not pack tight enough to keep as well as when cut. If the amount of silage to be put up will not warrant a farmer in owning a cutting outfit they can usually be hired in most neighborhoods upon about the same basis as a threshing machine. The silo may be filled all at once or gradually from day to day as may suit the owner's convenience. In slow filling the work should be done at least rapidly enough to prevent any mold from forming at the surface. In rapid filling a day or so must be allowed for settling and the silo filled up a second or third time so as to utilize all the space. In all cases it is important to have the forage packed into the silo as tight as possible. Tramp it very thoroughly around the edges.

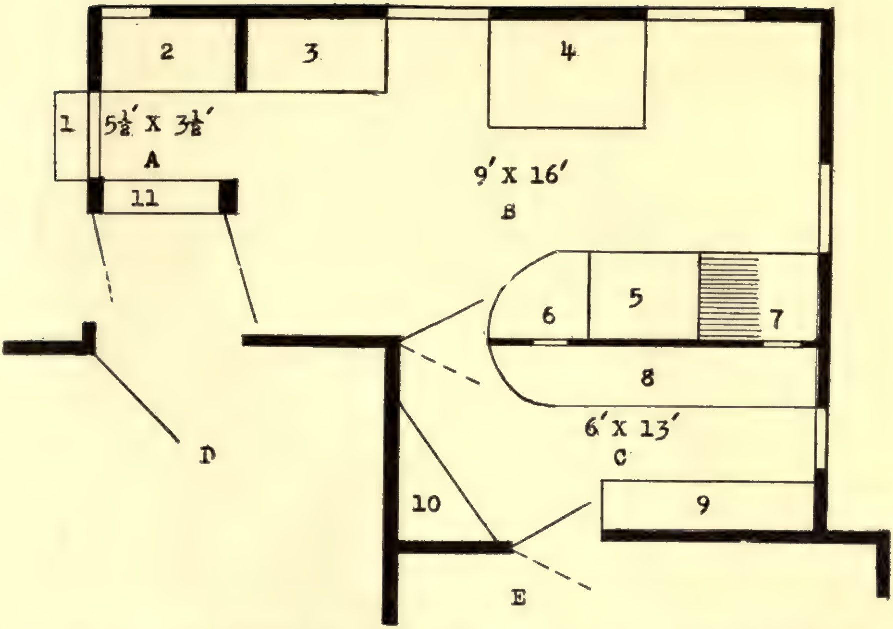
Crops for Silage—The crops most generally used for silage are: corn, sorghum, soja beans, winter vetch, clover, alfalfa, wheat, rye, oats and millet. Both stalk and ear of the corn are used. The following table shows the composition of various silage crops:

	Water	Ash	Crude Protein	Crude Fiber	Nitrogen Free Extract	Fat
Corn silage—mature corn	73.7	1.6	2.2	6.5	15.1	0.9
Corn silage—immature corn	79.1	1.4	1.7	6.0	11.0	0.8
Corn silage—ears removed	80.7	1.8	1.8	5.6	9.5	0.6
Clover silage	72.0	2.6	4.2	4.8	11.6	1.2
Soja bean silage	74.2	2.8	4.1	9.7	6.9	2.2
Cowpea vine silage	79.3	2.9	2.7	6.0	7.6	1.5
Canada pea vine silage	50.0	3.6	5.9	13.0	26.0	1.6
Corn cannery refuse—husks	83.8	0.6	1.4	5.2	2.9	1.1
Corn cannery refuse—cobs	74.1	0.5	1.5	7.9	14.3	1.7
Pea cannery refuse	76.8	1.3	2.8	6.5	11.3	1.3
Sorghum silage	76.1	1.1	0.8	6.4	15.3	0.3
Corn-soja bean silage	76.0	2.4	2.5	7.2	11.1	6.8
Millet-soja bean silage	79.0	2.8	2.8	7.2	7.2	1.0
Cowpea-soja bean silage	69.8	4.3	3.8	9.5	11.1	1.3
Rye silage	80.8	1.6	2.4	5.8	9.2	0.3
Apple pomace silage	85.0	0.6	1.2	3.3	8.8	1.1
Brewers' Grains silage	69.8	1.2	6.6	4.7	15.6	2.1

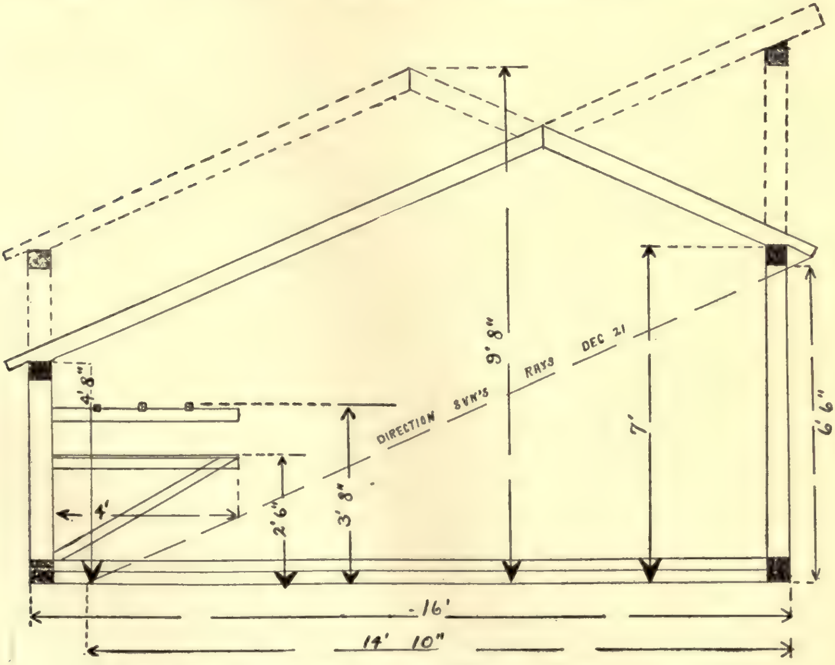
Feeding Silage.—When judiciously used silage can be fed with advantage to all classes of farm animals. It should not be fed as an exclusive coarse feed, but always in connection with some dry roughage. The nearer the maturity the forage is cut for the silo, the more silage may safely be fed, but it is always well to avoid feeding it excessively. The difference in the chemical composition and digestibility of the same forage green, and in the form of silage, is very slight and the relative feeding value of the different forms is dependent chiefly upon their palatability and physical effect. Silage is usually more palatable to animals than dry feeds and it acts as a mild laxative and keeps the digestive system in better condition than is usual with most dry feeds. Silage, green soiling, feeds, and pastures seem to keep the digestive system in about the same condition. Silage furnishes that succulency in a ration that seems necessary for stock to do their best work.—(Consulted and used in part. Purdue Univ. B. 40, 91; Md. Exp. Sta. B. 129; Off. Exp. Sta. Fr. Inst. Lec. 5; Va. Exp. Sta. B. 182; Iowa St. Col. B. 100; Cornell Univ. B. 167; Univ. Wis. B. 214; Univ. Mo. B. 48, 49; Mich. Agl. Col. B. 255; Bu. An. Ind. B. 136.)

FARM FENCES.

The fence problem is a serious one to the farmer, and as the supply of timber decreases the problem will increase. The time has passed when it is possible to build the old-fashioned rail fence, few



Plan of a Model Kitchen (Scale $\frac{1}{8}$ Inch is 1 Ft.): *A*. Cold Pantry; *B*. Kitchen; *C*. Butler's Pantry; *D*. Back Hall; *E*. Dining Room; 1. Window Box to Be Used to Keep Food Material in Cold Weather; 2. Refrigerator with Outside Door for Icing; 3. Kitchen Cabinet; 4. Range; 5. Sink with Shelves and Drainage Board on Either Side; 6. Door for Passage of Soiled Dishes to Be Passed Back; 7. Shelves in Pantry; 8, 9, and 10. Shelves with Glass Doors; 11. Shelves in Cold Pantry. Dept. of Agr. (See pages 101-104.)



Types of Roofs for Poultry Houses. Dept. of Agr.

hedges have been planted and are now considered objectionable, and all fences now being built are such as require posts, making the cost a matter of consideration. Wire is now in general use as a fencing material.

A very large proportion of the wire fencing manufactured and sold in the United States rusts much more quickly than it should. In many instances fencing which might reasonably be expected to last for ten or fifteen years will begin to rust and decay rapidly in less than two or three. Near the seashore and also in the neighborhood of large cities and manufacturing plants which pollute the atmosphere with sulphurous gases, wire fences will naturally rust much more quickly than under average rural conditions. Even under strictly rural conditions there has been noted a great difference in the life of wire, owing to prevailing climatic conditions, such as the general strength and direction of the wind and the amount of abrasive dust which is carried. After making all due allowances for these variations, it is none the less true that under perfectly normal rural surroundings there is still sufficient reason for complaint in many cases on account of rapid disintegration of wire fences.

The consuming public, in demanding lightness and apparent cheapness, is responsible in some respects for the rapid rusting and consequent destruction of wire fencing, so much complained of. The purchaser too often buys from the stock the local dealer has on hand regardless of the fact that none of it is well adapted for his especial needs. If the object is to purchase a fence which will last longest, instead of one whose first cost is the lowest, wire of the proper weight, and in which the stays are as large and heavy as is the line wire must be selected.—(Y. B. 1909.)

The kind or type of fence that is selected should depend upon the use to which it is to be put. A hog-tight fence needs a certain number of strong wires near the ground, while a cattle fence calls for a different design and must be horse high. In many cases a design of all 9-gauge wires can be selected which will answer every purpose, and cost no more, or even less, than the lighter-gauge fences ordinarily used. A general-purpose farm fence, hog tight and horse high, 58 inches high and containing 12 wires, should cost about 40 cents per rod if made up principally of 11-gauge bars and 12-gauge stays. It is probable that the heavier type would outlast the lighter by many years, but the initial cost is high. In many cases the consumer could select a fence that would answer every purpose—say one with 8 wires, 45 inches high, made up of all 9-gauge wires. If a fence of this type is not high enough for heavy stock, a single strand of barbed or smooth wire run along the posts about 6 to 10 inches above the top will add to its efficiency with a small addition to the cost. In other cases, where it is not necessary to fence hog tight, the fabricated wire can be set on the posts with a clearance at the ground, thus increasing its height. A systematic inspection in various parts of the country has shown numberless cases of fences made of 12 and 14 gauge wire, which in less than three years were rusting badly, to the great disgust of the owners. In many cases these were 12-wire fences, 58 inches high, or 10-wire fences, 52 inches high, although they were performing service for which 6-wire fence, 35 inches high, with perhaps a single additional wire, would have answered.

There is a practical limit to the increase of size in the wires and, except for certain special purposes, the use of heavier wires than No. 9 gauge is not recommended. Larger sizes increase the weight unnecessarily and the wires are so stiff that it is difficult for the user to handle and stretch the fabric. No. 9 gauge wire is strong enough for every practical purpose and can be made of low-carbon or so-called mild steel, which is much easier for a farmer to handle and fasten than high-carbon or spring steel.—(Y. B. 1909.)

Poultry Netting.—This form of wire construction naturally calls for a much lighter gauge wire than ordinary farm fencing. Poultry and rabbit fencing is furnished in a number of different designs by the manufacturers, but the kind most generally used is known as hexagon poultry netting. This is usually made in two different grades by the manufacturers. One grade is galvanized after fabricating or weaving the mesh; the other grade is made from about 20-gauge wire previously galvanized. It is safe to say that the second grade is not fit to use, and should never be purchased by anyone who desires to build a lasting structure. If first cost is a great consideration it would be wiser to make the poultry runs smaller and select the better grades of wire. It is easy to distinguish between these two grades of poultry netting, as that which is woven of wire previously galvanized will readily untwist, while in the other grade the twist will be found to be stuck together by the zinc coating.—(Y. B. 1909.)

There are several ways of adding to the life of fence posts. One method is by dipping in a solution of corrosive sublimate. The solution should have one part of corrosive sublimate to 150 parts of water. The salt is very difficult to dissolve, but if placed in a small amount of hot water the time required for dissolving will be shortened. It can then be diluted by adding the required amount of cold water. It is very poisonous and should be used with great caution. It is best to use the solution in wooden, cement or crockery vessels. The timber should be soaked long enough to allow the solution to penetrate the posts effectively. Another cheap process is treating with zinc chloride. Still another is by dipping the lower end of the post in crude petroleum to a sufficient distance to come above the ground line when the post is set, and then burning off the oil so as to char the end.—(Wy. E. S. B. 75; F. B. 320.)

Concrete Posts.—As a material for the construction of fence posts, concrete has not only very few of the disadvantages and practically all of the advantages of wooden posts, but it is also superior to timber in some respects. In the first cost concrete posts may be more or less expensive than the wooden posts, according to the locality. This depends upon the timber supply, the deposits of gravel and rock, and the skill exercised by the person making the concrete posts.

If manufactured as usual and cured for three months, concrete posts are as good as the best wooden posts of the same size. After three years' service wooden posts possess only from one-third to one-half of their original strength, whereas concrete grows stronger with age and needs no repairs, for neither weather nor fire injures it. Under ordinary circumstances, good concrete posts will last forever. Concrete posts are attractive in appearance because of their uniformity of size and color and, because of their durability, they effect a saving in giving greater life to the fencing material used, so that the permanent value of the property is increased.—(F. B. 403.)

Molds for Line Posts.—Molds for concrete line posts are made of both steel and wood, and are built for single posts or in sets or gangs. In deciding the size of the top and bottom of the post, and consequently of the mold, one should take into consideration the nature of the ground in which the post will be set. A very loose soil requires a post with larger ends and wider sides or a greater length for deeper setting in the ground. A careful observation of the smallest wooden post found satisfactory will help in deciding the size of the concrete post.

Steel Molds.—It is advisable to buy a form simple in its general shape, for in such a mold the reenforcing can be placed more exactly where it belongs. Steel has some advantages over wood, since it is lighter, less cumbersome to handle, and gives the post a neater finish and any shape desired. Where the appearance is important, steel molds are to be preferred to wooden. Neighbors can club together, when this is desirable, in order to buy steel molds and so economize in this expense.

Wooden Molds.—Wooden molds good enough for ordinary demands are very easily made. White pine is the best wood for this purpose. Cheaper kinds of lumber, which are easy to work with, may be used. Molds made of 2-inch planks, dressed on both sides, form neater posts, but lighter lumber may be used, if the forms are well braced. In imitation of the manner in which tree trunks grow, concrete posts are usually made tapering in size from butt to top. While this method may add a little to the appearance of the post and effect a slight saving in concrete, this saving is largely offset by the additional cost of the carpenter's work and of the lumber used in making the molds. Theoretically, the tapering post has a better design than the one with straight sides, but for ordinary use one is as good as the other. In making these molds, dressed lumber, planed from the rough, should be used. The proper dimensions for rough timber are 1 or 2 inches thick and 4, 6, 8, 10, or 12 inches wide; for dressed lumber they are 7/8 or 1 5/8 inches thick and 3 5/8, 5 5/8, 7 1/2, 9 1/2, or 11 1/2 inches wide.

Molds for Square Posts.—Molds for posts that are square or nearly square in cross section are simple and easy to make. They are built in three patterns: (1) For posts without taper; (2) for posts tapering on two sides; and (3) for posts tapering on all four sides. In order to avoid a sharp, irregular edge, neater posts are made by fastening a narrow strip of canvas or leather on the inside of the side board at the bottom of the mold, so that when the mold is put together and the concrete post molded the corner of the post will be rounded. A similar effect on the upper side of the post is produced by using a trowel or an edger—special tool for rounding the corners of concrete walks or curbs. Clay plastered in the corner of the mold or wooden strips tacked to the sideboards will answer the same purpose. Such strips must, however, be as small as possible or else they will crowd out much concrete, and thus cause the reenforcement to be located too far within the post to obtain the best results. Ordinarily the reenforcement should be placed within three-fourths of an inch or 1 inch of the outside of the post.

For Posts Without Taper.—The easiest and cheapest mold to make is the straight mold, or one for a post which does not taper. Such molds are merely long boxes built with various schemes for making the molding of the post a simple matter. On account of the amount of lumber saved and the ease with which these molds are filled, straight molds are generally made in sets or gangs, by constructing several side by side with a continuous bottom and end pieces. On account of the rigid method of construction, all lumber used in this mold, with the exception of the 2 by 4 inch stringers, may be 1-inch dressed boards. The end pieces are made up of one board each to which are nailed blocks 1 inch in thickness and 5 inches square, placed so as to allow the side pieces to slip between them. The end pieces are hinged to the bottom with strap hinges, in which the fixed pin is replaced by a loose pin or a nail. This arrangement allows the end piece to be removed at will.

For Posts Tapering on Two Sides.—Posts tapering on two sides are preferable to the straight posts in some respects. A satisfactory size for this style is produced in a mold 4½ inches deep by 6 inches wide at the butt, 4½ by 4½ inches at the top, and 7 feet long. These posts may be made more easily in gang molds, which are built so as to make the adjoining posts lie butt to top. By considering that the end positions of every post are reversed, it is possible to build this style of mold according to the directions set forth under straight molds.

For Posts Tapering on All Sides.—Square posts are also made tapering on all sides. A line post of a satisfactory size may be obtained by making the molds 5 inches deep by 6 inches wide at the butt, 3 inches deep by 4 inches wide at the top, and 7 feet long. Since all the butts must be placed at one end and all the tops at the other, this arrangement causes the continuous bottom to be 1 foot wider at one end than at the other.—(F. B. 403; Col. Exp. Sta. B. 161.)

Oiling the Molds.—Concrete has a tendency to stick to either steel or wood. In order to yield a smooth finish to the post, it is customary to give the inside of the molds a coating of oil. Soft soap or crude oils used sparingly serve the purpose well. Too much oil will destroy the setting qualities of the cement and will give a face roughened with pockmarks. A small amount of oil, poured into a pail of water and applied with a mop or stiff broom in scrubbing out the molds after they have been used five or ten times, or as often as necessary, will prevent the concrete from sticking.

Reenforcement is steel in the form of bars, rods or wires, buried in concrete to take up and to withstand the strains which tend to stretch or to bend the concrete. A concrete fence post is merely a small concrete column. Reenforced, it easily stands the strain from usage in a fence line.

Reenforcing should be placed near the outside wall, where it is reasonable to expect that cracks will open. For reenforcement, metal slightly rusted is as good as metal that is not rusted, if not better. In placing the reenforcing rods in position it is a wise precaution to bend them back at the ends. This takes only a little more time, but, if it is done, the reenforcement must be 2 inches longer to allow the metal to be turned back 1 inch at each end of the post. New barbed wire should not be purchased for reenforcement.

The danger section, or the point where posts are liable to break, is at the surface of the ground. For fences for lots and other places where posts may be subject to rubbing and crowding, short extra reenforcing pieces 2 feet long are sometimes placed in the post to lap this danger section. The corner of triangular-shaped posts which is not nearest the fence wire should, in theory, have heavier reenforcement than either of the other corners. If rods three-sixteenths of an inch in diameter, No. 8 wire, or two twisted No. 12 wires, are used in the other corners, a rod one-fourth of an inch in diameter, or two or three twisted No. 12 wires, should be placed in the threatened corner.—(Col. Exp. Sta. B. 161; F. B. 403.)

Molding.—After the molds, which, as a rule, lie flat, have been oiled or soaped, the concrete should be placed in them at once. If, for any reason, the concrete stands thirty minutes after mixing, it should be thrown away and a new batch mixed, for cement, if it has once partially set, makes weak, dangerous concrete, even though it is retempered by turning or adding water. After the molds are filled evenly to the depth of three-fourths of an inch or 1 inch, according to the spacing of the reenforcing rods or wires, the reenforcement should be laid in, properly spaced. The concrete should then be poured in until the molds are filled within three-fourths of an inch or 1 inch from the top, when the remaining reenforcement is fitted in place and the molds are completely filled. To render concrete more compact, a crowbar or a pinch bar should be placed under each corner of the mold successively and moved up and down quickly. This vibration makes the concrete more compact by shaking out the air bubbles, but there will be very few of these bubbles if the concrete is sufficiently mixed to proper consistency. If desired, the exposed corners of the post may be beveled with an edger and the open face given a neat finish by using a trowel immediately after the surface water has been absorbed and before the concrete has become too hard.

If wooden molds are used, they should be well soaked in water, so that the green concrete will not cause them to swell and thus crack the posts. The wind, the hot sunshine, and the frost are destructive to concrete; and, while it is an easy matter to protect the post from the first two agents, it is best to do no concrete work when the thermometer is below the freezing point, unless inside a building.

Curing.—It is a great mistake to believe that, when the molding is done, a concrete post is finished. The quality of the post must be determined by curing. The green post should be left in the mold until thoroughly hardened; that is, usually for two or three days. For square or nearly square posts the molds proper may then be removed and used on another bottom board, but the posts must stay on their bottom board in the shade and must not be disturbed for at least a week or ten days. Posts in triangular molds may be carried out, each in its own mold, after from five to seven days, and the post may be gently slid from its mold to a smooth floor covered evenly with a cushion of sand. While green the strain of lifting, or even a slight jar, will cause cracks, sometimes invisible, which greatly weaken the post. During the first two days of the life of a post it must be kept wet and covered with canvas, burlap, carpet, or any clean material. Sand will serve after the concrete has become hard, but manure will stain green concrete and otherwise affect it. The sprinkling should be continued up to the eighth day. After the tenth day, if the space is needed, the post may, with care, be placed on end in the same manner that wooden fence rails were formerly piled. A drop of only 6 inches often breaks a green post. Concrete posts gain rapidly in strength for the period of one year; they should, therefore, be made as long as possible before it is necessary to set them in the fence. No post should be used until it is at least 3 months old, and, to meet any contingency, a supply of well-seasoned posts should be kept on hand.

Building the Fence.—Posts should be placed so that the narrow side will support the wire. This will give the greatest resistance to breakage from animals rubbing against them or trying to get through the fence between the posts. The depth to which posts should be set varies with the character of the soil. Seven-foot posts are usually set from 2½ feet to 2 feet 8 inches deep. The earth about the post should be thoroughly compacted by tamping.

Methods of Attaching Wire.—There are numerous methods of attaching wire fencing to concrete posts. Some makers place staples or wire loops in the green concrete; others make holes in the posts. The former method is not desirable because the fastener can not be located exactly where the wire of the fencing will come when the post is set in the ground; then, too, the fastener will eventually rust or break off and will thus injure the looks of the post. On the other hand, holes through the posts weaken them and therefore this method is, in general, unsatisfactory.

The simplest, easiest, and cheapest way of fastening a wire fence to a concrete post is by encircling the post with a wire one size less than the corresponding wire in the fence proper and by twisting this wire around the strand of the fence. This is done in two ways. The fastening wire is placed around the post, twisted upon itself and then to the fence wire; or one end of the fastening wire is twisted around the fence wire, and the free end is then carried around the post and twisted on the other side of the same wire. Either plan is good, but care must be taken to draw the fastening wire tight, or else stock trying to get through the fence may rise or crush down the fencing with their heads. If any trouble is experienced, the post should be roughened at the fastening point with a cold chisel. Expansion and contraction of the fence due to heat and cold are cared for by the tension curves or kinks in the woven-wire fencing.—(F. B. 403.)

Conclusions.—Poured posts are easier to make than tamped ones. They are somewhat more expensive because one mold will make but one poured post per day, while the same mold may be used for making as many tamped posts as the builder can mix and tamp in the same time. According to the tests made poured posts are a little over 25 per cent stronger than tamped ones of the same size, mixture and reinforcement. Poured posts are not so porous as the tamped ones and are therefore more nearly water proof, thus making them better able to withstand the action of frost and alkali. The poured post is enough better in every respect to justify its construction and use in preference to the tamped one. Most commercial molds make a post which tapers from the base to the top, but the most economical mold is one which casts a post as large at the ground line as at the base, tapering from the ground line to the top.

The best form of post is one which is equally strong from all directions. The square, or round post, fulfills this requirement. The triangular post does not meet the requirements because it cannot be economically constructed so as to be equally strong from all directions.

To be economical, the amount of reinforcement should be in proportion to the size of the post and strength of the mixture.

The material used for reinforcement should be strong, light and rough enough to permit the mixture to get a firm grip upon it. It should be very rigid, with little or no tendency to spring or stretch.

The smooth reinforcement tends to slip even if hooked at the ends.

Two or more wires twisted together make as satisfactory a reinforcement as can be obtained.

Crimped wire tends to straighten and thereby breaks pieces out of the post at the point of greatest stress.

The reinforcement should be placed in each corner of the post at a depth of from ⅜ to ¾ of an inch from the surface.

There are several commercial wire fasteners now found on the market, the most of which are either cumbersome or expensive.

The posts should be cured in the shade for at least 60 days, the first 30 days of which they should be sprinkled daily.—(Col. Ag. Exp. Sta. Bul. 161.)

ROADS.*

Roads on the farm are subject to comparatively light travel; they may well be narrow. A very large number of farmers give scarcely any attention to building roads on their farms, but if the farm be large, and particularly if there be low spots here and there, the knowledge of how to make a good roadway is serviceable and valuable.

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* For illustrations, see pages 87, 267, 321, 339, 375, 429, 447, 519, 537, 555.

Grades.—It is advisable to avoid steep grades when possible. If the road must pass up a steep hill or mountainside, the steepness of the grade may be decreased by increasing the length of the road. In other words, eliminate steep grades by locating the road on curved or zig-zag lines, and not in a straight line from the bottom to the top of the hill. These curves should be carefully plotted and the straight stretches located with an instrument. This improves the looks of the road and does not add materially to its cost. Roads should never be located so close to stream beds as to be subject to overflow, or on ground which is constantly damp and marshy. The earth road should have at least six hours of sunshine each day. This can be secured either by locating the road with southern or western exposure, or by having such brush and trees as impede the drying action of the sun and wind removed. With gravel and stone roads, this is not so necessary, as a certain amount of moisture is needed on such roads, especially in the summer time.

Construction.—As soils differ for agricultural purposes, so they differ for roads. Clay or soils of fine texture usually make poor roads, especially if they contain much vegetable matter. The coarser soils, however, which contain some sand or gravel, will often make very satisfactory roads for light traffic provided they are kept in proper repair. If the road is composed of fine clay or soil, it will sometimes pay to resurface it with top soil from an adjacent field which has sand or gravel mixed with it. This method, called the top-soil method, is now in successful use in Clarke County, Georgia. If there is a road machine near that can be obtained, it will pay to get the use of it with an operator; one road machine with a suitable power and operator will do the work of many men with picks and shovels and do it better. It is a great mistake to put the working of the earth road off until August or September. The surface is then baked dry and hard. It is not only difficult to work but is unsatisfactory work when done. Earth which is loose and dry will remain dusty as long as the dry weather lasts and then turn to mud as soon as the rain begins. By using the road machine or hand labor in the spring of the year while the soil is soft and damp, the surface is more easily shaped and soon packs down into a dry hard crust which is less liable to become dusty in summer or muddy in winter.—(From Paper Read at First American Congress of Road-Builders, Held at Seattle, Washington, July, 1909, by Chief Eng. O. P. R., Dept. of Ag.)

Drainage.—It is better to have the ditches wide and shallow, rather than steep and narrow. Do not loosen, dig up, or plow up any more of the surface of an earth road than is absolutely necessary. The road should be gradually raised, not lowered; hardened, not softened. On flat lands, where water moves slowly, grading material should be taken from the lower ditch and culverts supplied where waterways occur. A shallow ditch on the upper side makes it possible to give culverts a good fall. It is often better to use two or more small pipes at least six inches apart than to use one long pipe. An attempt to drain mud holes with culvert pipe will fail in most cases. The water should be drained off by means of open ditches; the soft mud thrown out and replaced with just enough good firm earth to make it level (after being used for a little while) with the surrounding surface. If mud holes in earth roads are filled with brush or stone, it will usually result in two mud holes, one at each end.

Maintenance.—Repairs should be made when needed, and not once a year after crops are laid by. One hundred days labor, judiciously distributed throughout the year, will accomplish more and better work in the maintenance of an earth road than the same amount of labor expended in six days, especially if the six days are in August, September, or October, when the ground is hard and dry.

*The Split-Log Drag.**—Because of its simplicity, its efficiency and cheapness, the split-log drag or some similar device is destined to come into more and more general use. With the drag properly built and its use well understood, the maintenance of earth and gravel roads becomes a simple and inexpensive matter. Care should be taken to make the log so light that one man can lift it with ease, as a light drag can be drawn by two medium-sized horses and responds more readily to various methods of hitching and the shifting positions of the operator than a heavier one.—(From preceding paper on Roads.)

The best material for the drag is a dry cedar log, though elm, walnut, box-elder or soft maple are excellent. Oak, hickory, or ash are too heavy. The log should be from seven to ten feet long and from eight to ten inches in diameter at the butt end. It should be split carefully as near the center as possible and the heaviest and best slab chosen for the front. Holes are then bored perpendicular and at right angles to the split faces and in such a way that one end of the back slab when fastened in position will be about 16 inches nearer the center of the road than the front one. The two halves of the logs are fastened together by stakes, these being mortised into the holes above mentioned. A cleated board is placed between the slabs for the driver to stand on.

A strip of iron placed along the lower face of the front slab will prevent the drag from wearing. The drag may be fastened to the double-tree by means of a trace chain. The chain should be wrapped around the left hand or rear stake and passed over the front slab. Raising the chain at this end of the slab permits the earth to drift past the face of the drag. The other end of the chain should be passed through a hole in the opposite end of the front slab and held by a pin passed through a link.

For ordinary purposes the hitch should be so made that the unloaded drag will follow the team at an angle of about 45 degrees. The team should be driven with one horse on either side of the right hand wheel track or rut the full length of the portion to be dragged, and made to return in the same manner over the other half of the roadway. Such treatment will move the earth toward the center of the roadway and raise it gradually above the surrounding level.

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* For illustration, see page 87.

The best results have been obtained by dragging roads once each way after each heavy rain. In some cases, however, one dragging every three or four weeks has been found sufficient to keep a road in good condition.

When the soil is moist but not sticky the drag does its best work. As the soil in the field will bake if plowed wet, so the road will bake if the drag is used on it when it is wet. If the roadway is full of holes or badly rutted, the drag should be used once when the road is soft and slushy. This is particularly applicable before a cold spell in winter, when it is possible to so prepare the surface that it will freeze smooth.

Not infrequently conditions are met which may be overcome by a slight change in the manner of hitching. Shortening the chain tends to lift the front slab and make the cutting slight, while a longer hitch causes the front slab to sink more deeply into the earth and act on the principle of a plow. The advantages to be gained from the persistent use of a road drag may be summarized as follows: (1) The maintenance of a smooth, serviceable earth road free from ruts and mudholes; (2) obtaining such a road surface with the expenditure of very little money and labor in comparison with the money and labor required for other methods; (3) the reduction of mud in wet weather, and of dust in dry weather. There are also several minor benefits gained from the use of a road drag, besides the great advantages which always accrue from the formation of improved highways, of which may be mentioned the banishment of weeds and grass from the dragged portion of the road.—(Agr. Dept. B. 321.)

The tendency of the people to leave the rural districts and gather in towns and cities is alarming to thoughtful men all over the country. Wherever good roads have been constructed the people would rebel against a return to the old system.—(P. R. C. 33.) Good roads are something that we all ought to have. Next to common schools, good roads will benefit the people as much as any other one thing they can have.—(P. R. C. 32.) The price of a thing at the railroad station is fixed by the state of the markets of the world. The farmer gets the same for what he sells, and pays the same for what he buys, whether he lives one mile away or twenty. So the whole cost of hauling, and that in both directions, comes out of his pocket.—(Tenn. A. E. S.; Vol III.)

By actual test the same force which draws 1 ton on a muddy earth road will draw 4 tons on a hard macadam road. On the improved roads in New Jersey loads of 4 to 5 tons are habitually drawn by a two-horse team. This effects a saving of fully three-fourths of the cost of hauling to the station, and reduces the cost of road transportation. Many hundreds of miles of good roads have already been built, in localities widely separated, under varying conditions, and through various methods of administration, finance, and construction. The agitation for good roads rests on two distinct bases: business economy in transportation, and pleasure.—(P. R. B. 17.)

Money Value of Good Roads to Farmers.—This will be granted by all. That the money value of improved highways is alone sufficient to justify the cost of their construction will be confidently claimed or readily admitted by many farmers, questioned by others, and denied by not a few. Speaking, therefore, in behalf of those who for any reason are not influenced by the higher considerations in favor of improved highways, the question may be raised: Will it pay the farmers in dollars and cents to improve their public roads?

Before attempting to answer this question, let us consider in what ways permanently good roads will prove financially beneficial to farmers. All will agree, we think, that a good road will: (1) Economize time and force in transportation between farm and market; (2) enable the farmer to take advantage of market fluctuations in buying and selling; (3) permit transportation of farm products and purchased commodities during times of comparative leisure; (4) reduce the wear and tear on horses, harness, and vehicles; (5) enhance the market value of real estate.

Many intelligent farmers will not accept the estimates of their fellow farmers as to the money value of good roads—many will even deny that improved highways have any appreciable money value. It is true, however, that many of these very same farmers favor good roads, and would aid in their construction for the same reason that they would build for themselves comfortable and even luxurious homes.—(P. R. C. 23.)

An example of the increased land values brought about by road construction is found in the vicinity of Jackson, in Madison County, Tennessee. The construction was begun in June, 1903. Within one year the land values throughout the county had increased, in many instances from 20 to 100 per cent, and the city property greatly advanced in value. The report says: There are no houses to rent in Jackson; builders are busy, numbers of new real estate offices have been opened, large tracts of farm land are being subdivided, and prices are being paid which astonish the most far-seeing champion of this now popular movement.

New families from adjoining counties and states are constantly coming in, some to make their homes in the city and others wanting farms on the good roads. Still others, looking ahead and anticipating profits, have made purchases 5 and 6 miles back from these roads, paying largely increased prices.—(Ag. Dept. Y. B. 1903.)

The great problem of roads in many parts of the country is not one of bad roads to be overcome by macadam, but a problem of grades. The roads often go straight up the hills rather than climb them by easy grades.

The original roads were rarely laid out with any regard to grades. They were laid out before the days of railroads. They may have had some relationship to the location of early villages but usually have no relationship to the location of present railroad stations.

In some cases the roads are laid out in squares. In this case it results in having nearly all the roads go straight up the hill from the railroad for 400 to 800 feet.

When new grades can often be established at so small a cost it is poor economy for generation after generation to continue going straight up the hills rather than around them. There is need for a road system laid out in each county that will connect the farms with the towns, rather than connect cities with cities. The latter are, of course, needed, but their chief use is by city persons and not by farmers. They can never solve the farm problem because they serve so small a percentage of the farmers.

A road census, made in 1904 by the Office of Public Roads, United States Department of Agriculture, revealed the fact that there were 2,151,000 miles of public roads in the United States, of which only 7.14 per cent were improved. This census also showed that the total annual expenditure for roads in the year 1904 was $79,000,000, or an average of about $37 per mile, and of this amount $19,000,000 was represented by taxes that were payable in labor on the roads, and this, in fact, reduces the cash expenditure for that year to an average of about $27 per mile.—(Ag. Dept. Y. B. 1910.)

How Local Public Roads Have Been Obtained.—For some time public sentiment through the country has been growing in favor of a reform in the old system of public road administration. This sentiment first found tangible expression in a law passed by the New Jersey Legislature in 1891, providing among other things for an annual appropriation of $75,000 from the State Treasury. The State appropriations have gradually been increased each year until the amount available from that source for State aid in road building in 1910 was about $500,000.

Following closely the example of New Jersey, Massachusetts in 1892, Connecticut in 1895, and New York in 1898, established State highway departments with State aid, or took steps looking to that end. New York State affords a striking instance of development from a purely local to a highly centralized system.

Under the present law, which became effective January 1, 1909, a State highway commission, consisting of three members, was provided for, together with a system of about 2,800 miles of State roads, to be improved and maintained solely at the expense of the State. The county roads are to be improved jointly by the State, the county, and the towns. The town highways are to be improved and maintained by the towns with funds locally raised and supplemented by the State aid apportionment, which is to amount to from one-third to one-half of the entire cost, according to the assessed valuation of real and personal property for each mile of highways in the town. Under this new law the State highway commission has supervision, either directly or indirectly, over every mile of public highway in the State.

While the funds for the town highways are expended locally, still they are under the supervisory direction of an official of the

State highway department. Improvement of State and county highways is carried on wholly by contract. Plans, specifications, and estimates are prepared by the State highway commission, and, in the case of county roads, are submitted to the board of supervisors of each county involved for final approval. The State highway commission is given the power to accept or reject the improvement when finally completed.

Other States have adopted the plan of State aid and State supervision in some form. Some few of these have only State departments for investigation and supervision, others furnish State aid only in the form of convict labor, while most of them furnish State money aid with State supervision. Among those having State highway departments for investigation and supervision, but which do not give money, are Iowa, Kansas, Missouri, North Carolina, and Wisconsin.

The State of Illinois, in addition to the investigative and supervisory work of the State highway department, extends its aid in the actual work on road improvement by maintaining a crushing plant. It operates it by the use of State convicts and distributes crushed rock for road-building purposes to the various counties throughout the State on application of the county officials. No charge is made for crushing this rock and placing it on board the cars at the crushing plants, but the freight charges have to be paid by the county.

The State of West Virginia in 1909 passed a law making a direct appropriation from the treasury for the construction of State aid roads and also placing both the State and county convicts at work upon its highways. Virginia also provides convict labor, and makes an annual appropriation of $250,000.

Arizona, Colorado, New Mexico, Florida, Georgia, Louisiana, and North Dakota extend aid by the use of convict labor. In this form of aid Georgia probably takes the lead of any state in the Union. Both State and county convicts are worked upon the roads each day in the year, and a force of about 4,500 convicts is working a wonderful reformation in road conditions throughout that State.—(Ag. Dept. Y. B. 1910.)

Lessons as to the Best Means.—The present trend of road affairs throughout the various States is toward a reform in administration and the adoption of a more progressive policy. The old system of paying road taxes in labor has proved inefficient and is being rapidly discarded for the better plan of requiring all road taxes to be paid in cash. It is also apparent that the State will ultimately be the unit of administration and will largely control and direct road work in the counties and townships. A reduction in the number of road officials is also inevitable, and knowledge and skill in road building will be required of each official. The necessity for skilled supervision is being recognized in every State, and is being met by the appointment of competent highway engineers. In many States the State highway departments employ a corps of highway engineers, and different counties throughout these States also employ county highway engineers, while in many of the States not having State highway departments the counties are engaging the services of skilled engineers to supervise their road work. This step marks one of the greatest strides yet made toward the abandonment of old and inferior methods of highway administration, construction, and maintenance. All of these reforms, as well as other reforms in methods of construction and maintenance and a gradual improvement of road conditions, are being rapidly brought about, and largely through the agitation and work of the United States Office of Public Roads, the State highway departments, and the various highway associations throughout the country. The outlook for road legislation is exceedingly bright. Already members of the legislatures of various States and of various organizations, having for their purpose the improvement of highway conditions throughout the country, are formulating highway bills with the hope of having them enacted into law. In every State the sentiment is strongly in favor of effective highway legislation, and in most of the States not having already adopted it new legislation, either enacted or pressed for enactment, will embrace in some form or other the principle of State aid or State supervision.—(Ag. Dept. Y. B. 1910.)

It is largely due to the system of localized control and payment of tax in labor rather than in cash that so comparatively little in the way of good results has been accomplished in the past, for the reason that it fails to insure skilled supervision, provides an inadequate revenue, depends upon a purely unskilled and unreliable class of labor, and practically precludes any construction of a permanent character.—(Ag. Y. B. 1910.)

The laborers bring such tools as they happen to have regardless of their adaptability to road work. The teams are usually too small and are not trained for such work. The rule is to work the roads once a year after the crops are laid by; but our heavy spring rains damage roads more or less, and such damage should be repaired promptly. This labor-tax plan leaves the roads at the end of the year about in the same condition they were in at the beginning, and, if continued, at the expiration of twenty or more years we will still have just such roads as we now have. This plan has been tried so long and so extensively that even the wayfaring man need not err in what to expect from it.—(Miss. A. E. S. B. 60.)

The following facts picked out from arguments used in a successful campaign for State aid in Minnesota, illustrate the advantages in having the road burden of the country districts partially met by the State at large. Permanent road building is not accomplished by ordinary highway work, but by constructing roads that will take care of themselves for a reasonable time. Permanency should be considered with reference to locality, travel, and other kindred conditions, and should not be made too expensive. Extravagance is a danger to be avoided as one that will imperil the whole enterprise. We should regulate our progress in this respect by practical economy.

With the modest State fund provided for in the amendment the State can encourage counties by helping them build some sensible roads adapted to prevailing conditions. It will also encourage the best men found in road work to become experts in road making. It will have an influence in checking the use of money and labor in ways which result only in poor roads and disgusted taxpayers. While the bill provides State funds for country roads, townspeople generally favor it. Under this law graded dirt roads and bridges will doubtless be the first concern, graveled surfaces will come next, and, in a few of the richer counties, stone surfaces and other expensive roads may be made as samples. The bill will not injure nor antagonize anyone, but will greatly help the entire State.

The proposed plan for State aid is thought to be practical and a marked improvement over the existing method of using State aid in highway improvements. The use annually, under the direction of a State highway commission, of a permanent road and bridge fund in every county in the State which appropriates a double amount for the same purpose will operate to complete some particular road every year, and in a few years the improvement should be very noticeable throughout the State.—(Public Roads Cir. 32.)

Co-operative Work on Public Roads.—Some road reformers think, as thought many of the founders of the Republic, that the General Government should aid in the building of the principal roads. This idea, however, has met with little encouragement; but out of the agitation has grown a law, passed by Congress in 1893, providing for an office in the Department of Agriculture to collect and disseminate information on the road subject, to conduct investigations, inquiries, and experiments regarding road materials and road construction, and to encourage, by object lessons and otherwise, the building of better roads.—(Agr. Dept. Y. B. 1899.)

Any person residing in the United States may have materials tested free of charge by applying for instructions and blank forms to the office of Public Road Inquiries or to the road-material laboratory, Bureau of Chemistry. Besides testing road materials, blank forms for recording traffic are supplied by the Department to anyone intending to build a road. When these forms are filled and returned to the laboratory, together with samples of materials available for building the road, the traffic of the road is rated, each property of the material is tested and similarly rated according to its degree, the climatic conditions are considered, and expert advice is given as to the proper choice of material to be made.—(P. R. An. Rept. 1909.)

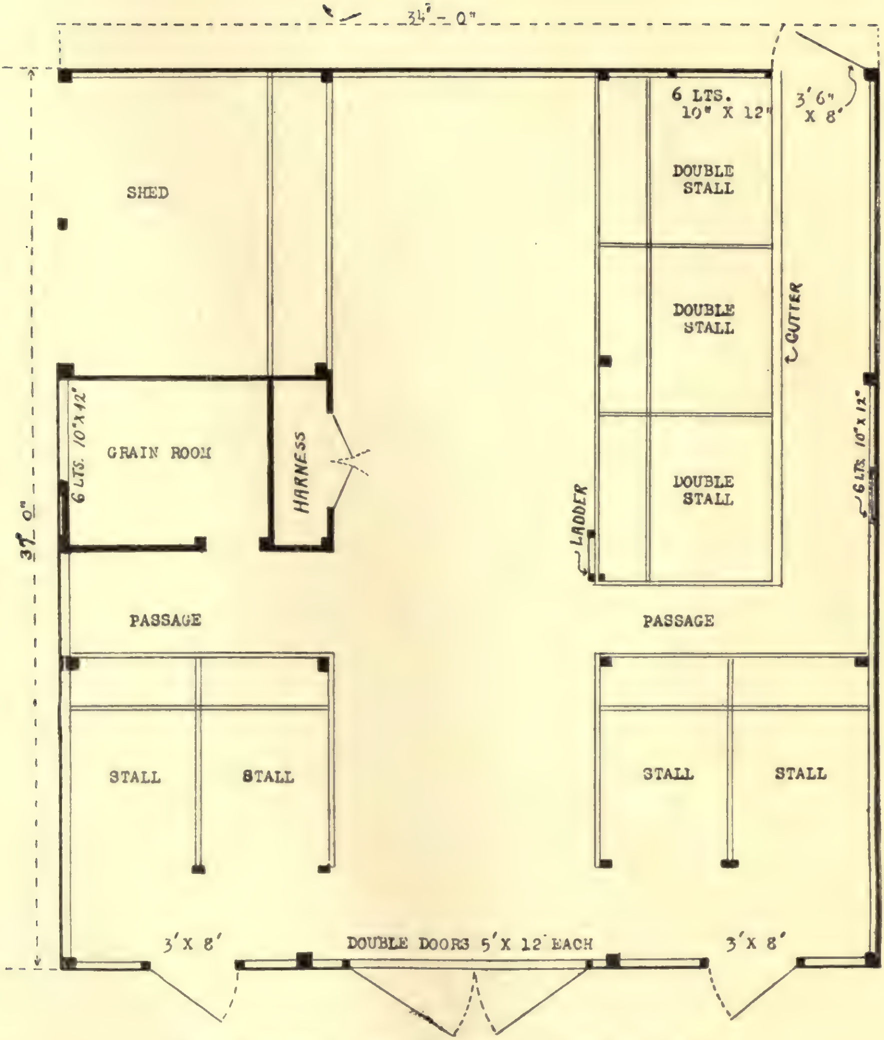
During the year 1910, lectures, addresses and papers numbering altogether 523 were given over a wide range of territory, embracing the States of Alabama, Arkansas, Delaware, Florida, Georgia, Idaho, Illinois, Indiana, Kansas, Kentucky, Louisiana, Maryland, Michigan, Mississippi, Missouri, Nebraska, New York, North Carolina, North Dakota, Ohio, Oregon, Pennsylvania, South Carolina, Tennessee, Texas, Utah, Virginia, Washington, and West Virginia, and the District of Columbia. A large proportion of the addresses was given at farmers' meetings in small towns and villages, but the work included a great many lectures and papers before scientific organizations and conventions of road builders and road officials. In view of the fact that the widespread dissemination of information is essential to the betterment of road conditions, it is believed that giving lectures of a practical character is productive of excellent results.—(P. R. An. Rept. 1910.)

Cooperating With Counties.—Fully believing in the beneficial results that follow object-lesson teaching, not only in institutions of learning, but in the progress of the world, the Director of the Office of Public Road Inquiries undertook to demonstrate the benefits resulting from this method by building object-lesson roads in different parts of the country. The work was undertaken on the principle of cooperation in the following manner: This Office furnishes the plans, specifications, scientific information, instructions, expert road builders, didactic literature, and all the machinery required in the construction of the road, and provides for testing all road-building material in the laboratory at Washington, D. C. The communities having the road built are required to furnish all necessary materials and common labor.—(P. R. An. Rept. 1903.)

The advisory work of the Office consisted of 242 assignments during the past year, which may be classified as follows: Advice in regard: (1) To various methods of road construction, including macadam, gravel, earth, sand-clay, burnt clay, bituminous, slag, brick, and oiled earth; (2) to surveys for proper location of roads; (3) to the use of convicts on roads and housing them during the continuance of the work; (4) to preliminary inspection of conditions and location of roads where object-lesson roads are requested; (5) to new methods of construction to be used experimentally; (6) to the treatment of driveways at the Washington Indian School, Puyallup, Wash.; (7) to the construction of bridges; (8) to oil-concrete flooring for bridges; (9) to devising model systems of roads for counties, and the best methods of construction, maintenance, and administration; (10) to the destructive effects of automobiles on roads; (11) to bond issues for raising funds for road construction; (12) to the use of the split-log drag; (13) to the investigation of road materials; (14) to the use of concrete on farms. This branch of the work is constantly growing in importance as the corps of engineers, chemists, and experts of the Office is now looked upon as a high-grade body of consulting specialists from whom reliable advice may be procured concerning difficult and peculiar problems such as are not capable of easy solution by local authorities.—(P. R. An. Rept. 1910.)

How to Get Good Roads.—Enough has been said already to show that, through the application of State aid, good, permanent roads can be built without increasing the burdens of the farmer, and all experience has shown that the expense to the State and county is much more than balanced by the increase in taxable values of the districts through which the roads are built.—(P. R. B. 17.)

What can the farmer who, seeing the immense advantages in better roads for his township, county, and State, do toward aiding in bringing them about? Although individual effort in a public



Farm Barn for Mixed Husbandry. Dept. of Agr.

question is limited in its effect, yet any single farmer may help this movement in two ways: First, by using his influence for better road legislation within his township and county; and, second, by using his influence together with that of his neighbors in impressing upon the members of the State Legislature from his district the urgent need for further State aid in cases where such aid is not already sufficient.

The influence that even one farmer can exert was well shown in the mass meeting of the farmers of Madison County, Tennessee, which was held following the winter of great mud in that district, 1902-3. When it came, the burden could no longer be borne—the roads were impassable; it required two strong mules to draw a milk wagon with two milk cans, and all day was consumed in going a few miles. For more than six weeks this condition prevailed. No one attempted to pass over these mud roads except in case of dire necessity. The farmer was locked in and all trade was stopped. The opportune moment had arrived; a mass meeting of all the citizens of the county was called, and those who could get to it came. All wanted good roads, the only difference of opinion being as to the best means for procuring them, and after a long discussion which seemed likely to prove disastrous, some contending for a direct tax and a few roads each year, and others wanting to issue bonds, a farmer arose and addressed the meeting as follows:

Mr. Chairman, I am just a plain farmer and have no business trying to talk in this meeting. I am all covered with mud; there is mud on my boots and all over my clothes, and my hat is all spattered up, too. I walked to this meeting because my horse couldn't travel the roads. I've got a little farm and sawmill out on the Poplar Corner road, just a little over 2 miles from town, and if I could climb up on a hard road with my truck and what lumber I've sawed I could clear enough in one day to pay my tax on that road; but I haven't got it.

I bought some groceries from you (turning to a merchant) this month; yes, $5 worth, for I carried them out on my back; but if I had a good road, it would have been $25, I am sure.

This plain statement brought the question home, a hearty laugh went round, and a motion prevailed, without opposition, to instruct the representative in the State legislature to draft a bill authorizing the county court to issue bonds in the sum of $300,000, bearing 4 per cent interest, and extending over a period of thirty years.

The bill immediately became a law. It provided that the first $150,000 should be used in the construction of roads within a radius of 5 miles from the corporate limits of the city of Jackson, and the second $150,000 in the construction of roads within a radius of 10 miles from the corporate limits.—(Ag. Dept. Y. B. 1910.)

The farmer may use his influence toward the appointment of a competent county engineer.

Work, whether of brain or muscle, has its market price as well as wheat or corn, and is not to be had for less. An engineer, if competent to supervise a county's roads, will demand a good salary. A willingness to serve for less than $2,000, without satisfactory explanation, should be considered sufficient evidence of incapacity. Fitness should be the sole test of eligibility. Such things as his place of residence, his skill in organizing primaries, his views on the tariff, predestination, or infant baptism, should never be considered. When once appointed, he should be given full charge of all the county's roads and bridges, and no bills should be paid or contracts awarded until approved by him. His term of office should expire when his work shows bad results, and not before. Of this the appointing power should be the sole and final judge. This brings us to the most important question.

The appointment should be shielded from political influence with jealous care. If the State has an Engineer of Roads and Bridges the appointment should of course be made by him. If not, an appointment made by a board composed of the Chancellor and Circuit Judge might result as favorably as any.

If any considerable number of farmers in a county become enthusiastic on the good roads question, they can aid in effecting such of the above reforms as have not been brought about in their locality. The farmer who is enthusiastic about roads may, by spreading the enthusiasm among his neighbors, materially aid in overcoming such difficulties as these.

The farms of the United States comprise less than one-fourth of the total property of the country, yet that small fraction has until recently paid the whole cost of building roads. The injustice of this system, which was inherited from the old countries, but which was abolished there many generations ago, is not yet fully appreciated by the farmers of this country and one great difficulty now experienced in road improvement is in getting the farmers' consent to have this injustice wiped out and in inducing them to accept the aid which many cities and towns are willing and anxious to give to the general improvement of the highways.

The co-operation of cities and towns with the farmers in good road building has been in some cases freely volunteered, but it is much more effective when regulated by State law. The yearbook for 1895 discusses under the head of Co-operative Road Construction, the various methods of contributive action. Since the date of that writing the progress of New Jersey, Massachusetts, California, Connecticut, and Rhode Island in this direction has been constant and satisfactory, and the same general principle of State aid given to localities which volunteer to contribute on their own part is being strongly advocated in many other States. It is probably the only method in which the aid of cities and towns can be generally and practically applied. The effort of the Office of Road Inquiry has, therefore, been constantly directed to this end and in most of the States which are generally aroused to the need of road improvement legislation for State aid is very actively urged. Several States are proposing amendments to their constitutions in order that this legislation may be accomplished.

The fact that some people who will oppose all attempts to improve the highways because of their lack of appreciation of the advantages that will result therefrom often change their minds when the improvement has been made in spite of their opposition, is abundantly illustrated by the case of Capt. S. B. Alexander, author of the famous Mecklenburg road law of North Carolina. When a member of the legislature of that State, in 1878, he introduced a bill which afterwards became a law, providing for a general tax upon the property of the entire county, both city and country, the proceeds of which were to be devoted to the permanent improvement of the roads in Mecklenburg County. The people who had elected Captain Alexander to the legislature were so much displeased at this action that he was defeated at the next election, and his successor in office was elected to effect a repeal of the obnoxious law. This was done. The law was in force long enough, however, to produce a few miles of good road in the county, which served as an object lesson to educate the people. By the time another two years had elapsed and a new legislature was to be chosen Captain Alexander was reelected, with instructions to secure the re-enactment of the original law. The law has now been in effect for many years, being of great advantage to the people and producing a transformation of the entire county. The law and its author have both become famous. Captain Alexander was elected to Congress, and the Mecklenburg road law is regarded as a model of road legislation in the entire country, especially in the Southern States. One may travel a thousand miles in a southwesterly direction from Washington without seeing an improved highway except in Mecklenburg County; but as soon as the boundaries of that county are reached, any passenger can tell where he is by the excellent appearance of the highways and the advanced condition of agriculture. This is only one of many instances that could be given, but it is the best to illustrate the general rule.—(Ag. Dept. An. Rept. 1903.)

The problem of laying out roads in each county which will connect the farms with the towns is often too large for counties because many of the roads would cross county lines. The state may well be appealed to to plan such road systems and to help in their construction. Such roads would be good dirt roads with easy grades. In many cases there are too many roads, so that money is wasted in half keeping them up. Such a survey should freely abandon old roads as well as make new ones. Complete surveys and plans should be made at one time so that all road improvements may be made with reference to the final plan.—(Ag. Dept. B. 295.) State aid, wisely offered, will incite local interest, and local interest once aroused becomes the strongest factor in solving the problem of good roads. To the road improvement of every town there should be offered a State supervision which gives to each town the benefit of the experience of all the towns, and which enlightens local authority rather than supersedes it.—(P. R. Cir. 33.) It is only through State aid that those cities and villages which are quite ready to assist in road building can make that aid available.—(P. R. B. 17.)

It may happen, however, that the difficulty in getting adequate State aid does not lie with the farming community, but rather with certain elements of the city population who oppose being taxed to support country roads. Opposition of this kind was encountered in Minnesota during the successful campaign for State aid in 1904. This opposition was met in that State and may be met in other instances by the farmers using such clear cut arguments as the following: The tax-paying property of most States consists chiefly of farm and city property. The exact ratio of value between the two is not known, but more than one-half of the taxable property in many States is in the cities and villages, with a continual tendency, as the State grows older, to increase the value of city property as compared with the value of farm property. It is easy to see that the burden of taxation to improve the streets of the cities must be very light as compared with the burden of taxation which will be necessary to make equally good roads in the country, provided the city property is to be taxed for none but city roads and the farming property must pay taxes for improving all the country roads. It is absolutely impossible for the farmers to do it. With this state of affairs, is it any wonder that the cities have better roads than the country districts? With so much more money and with so much less territory, the cities have a very unfair advantage over the country districts. The country roads never have been, ought not to be, and never will be improved at the sole expense of the farming property.

Now the business men of the cities have learned that it is to their interest to have better country roads, and they have been scolding the farmers because they have not been building better roads. The farmers very properly answer that they can not afford to improve so many miles of road with their small means. As a result the idea has occurred to some that, since the whole State is interested in the improvement of all the roads, and since the city people are anxious to have the country roads improved and are insisting that they shall be improved, it would be fair to levy a tax on city property as well as country property for the improvement of country roads. This is what is meant by State aid. In plain, blunt language, State aid means to the city people, either put up or shut up.—(P. R. Cir. 33.)

The agitation which has become so universal will surely result in a well-defined public sentiment that will soon overcome all obstacles. With the new century, the good-roads movement is likely to receive valuable aid from the owners of horseless vehicles, already not uncommon on our thoroughfares. The aid of these new allies, added to that of the farmer, with his great pecuniary interest in the question, promises well for a rapid spread of the movement throughout the country.—(Ag. Dept. Y. B. 1899.)

(The following authorities have been consulted and extracts taken from their writings in the preparation of this chapter: Ag. Dept. Bs. 295, 321; Y. B. 1899, 1903, 1910; Of. Pub. Roads, B. 17;

An. Repts. 1903, 1909, 1910; Cir. 23, 32, 33; Tenn. A. E. S. Vol. III.)

STATISTICS.

Foremost among countries in agricultural resources, equipment, and production, the United States affords an interesting and important subject for statistical examination with respect to agriculture. Here is a country covering the breadth of the North American continent and extending almost to antarctic regions on the north and fully to semitropical regions on the south covering a great area of land surface and within this great area the variations in soil, altitude, heat, moisture, rainfall, and other agricultural conditions are so numerous and so considerable in degree, that the products of agriculture are of many kinds and bountiful, so that the world market is largely affected by many of them.—(Ag. Dept. Y. B. 1897.) Prices of agricultural products are primarily governed by the law of supply and demand; therefore, early information concerning the supply is of value to all. Those who produce and those who consume are vitally interested, as well as the dealer who stands between them.—(Bu. Stats. Cir. 17.)

The Bureau of Statistics issues each month detailed reports relating to agricultural conditions throughout the United States. Beginning with planting, data are gathered and reports made as to the condition and acreage of each of the principal agricultural products, such as corn, wheat, oats, rye, barley, potatoes, hay, cotton, tobacco, rice, etc. As the crops progress the prospects are reflected in monthly condition reports upon each growing crop; such reports being expressed in percentages, 100 representing a normal condition. A normal condition of 100 would be the condition of the plant where it gives promise of such a crop as might be expected if the plant were not subjected to damaging influences, but grew bountifully and under favorable conditions, including favorable weather, freedom from damaging insects, etc. A normal crop is not a crop which might be raised by exceptional skill or by an exceptional farmer, but such a crop as, planted and cultivated, will be produced if not subjected to damaging influences. Condition reports, expressed in percentages of a normal crop, when published, are coupled with a statement of the averages of similar reports at corresponding dates in preceding years (usually ten-year averages); by such comparison the condition of crops in comparison with the average condition is readily obtained. At harvest time the yields per acre are ascertained, which, being multiplied by the acreage figures already ascertained, give the production or quantitative figures for the year.

Eleven monthly reports on the principal crops are received yearly from each of the special field agents, county correspondents, State statistical agents and township correspondents, and one report relating to the acreage and production of general crops annually from individual farmers.—(Bu. Stats. Cir. 17.)

Value of Government Crop Reports to Farmers.—The question is frequently asked, Of what value are Government crop reports to farmers? The Government crop reports are especially valuable and beneficial to farmers, who are benefited by them both directly and indirectly. All farmers benefit by them in an indirect way, but only those who read these reports and keep posted by them are benefited in a direct way.

It is well known that speculators and large dealers in farm products do not depend entirely upon Government reports for information concerning crop conditions. They have traveling agents and correspondents (usually local buyers) throughout the United States, who keep them posted; and the large buyer or speculator, in return, gives to these local buyers or correspondents information in regard to general conditions. These local buyers know the conditions of crops in their vicinity better, as a rule, than the average farmer, because it is their business to keep well informed. The farmer can not, by refusing to report for his locality the condition of crops, prevent buyers or speculators from knowing the condition of the crop. But how about the farmer, if Government crop reports, which are made up largely by and for him, should be discontinued? He may know very well the condition of crops in his own locality, but he must depend upon reports of others, in the newspapers or otherwise, for the conditions of the entire crop. Prices in his local market are influenced, as a rule, more by the condition of the whole crop than by local conditions. The entire wheat crop of his county may be destroyed and prices be low, if the entire crop is large, or his county may have a bumper crop and prices be very high, if the entire crop be short.

Some private crop reports published in newspapers are honestly prepared and more or less reliable; on the other hand, misleading crop reports are frequently sent throughout the country to affect prices in the interest of speculators. Does the average farmer know which reports are reliable and which are sent out to mislead? The Government reports are intended to enable farmers to keep themselves informed as to the general conditions. The question, then, resolves itself to this: Does it benefit the farmer to keep posted?

But even those farmers who do not keep posted are indirectly benefited by the publication of Government crop reports, for these reports check and lessen the injurious effects of false reports sent out in the interest of speculators. As a police and constable force tends to check but not entirely prevent crime, so Government reports check but do not entirely prevent the circulation of false and injurious reports.

The more certainty there is as to the supply of and demand for a crop the less hazard or speculation there is in the business of distributing the crop, to the benefit, in the long run, of both producer and consumer.

Large manufacturing firms, agricultural implement or hardware companies, who neither buy nor sell farm products, are much interested in the prospects and conditions of crops. This knowledge enables them to distribute more economically their wares, sending much to sections where crops are good and farmers have the power to buy, and less to sections of crop shortage, and therefore with less buying power. Few farmers realize how much is saved by the even distribution of wares which they buy, which is secured from a knowledge of crop prospects. In this saving farmers in the long run are benefited.

It is important to railroads to know the profitable size of crops in the country in order to provide sufficient cars to ship the grain. The more nearly they can learn the size of the crops the better able are they to move them economically. Here, again, in the long run, farmers are indirectly benefited by the cheaper distribution of the crop, due to better information of crop conditions.

Under modern trade regulations and conditions, prompt and reliable information regarding agricultural areas, prospects, and yields is also an important factor in the proper conduct of commercial, industrial, and transportation enterprises. The earlier the information regarding the probable production of the great agricultural commodities can be made public, the more safely can the business of the country be managed from year to year.

Retail dealers in all lines of goods, whether in city or country, order from wholesale merchants, jobbers, or manufacturers the goods they expect to sell many weeks, frequently months, before actual purchase and shipment. Jobbers follow the same course, and manufacturers produce the goods and wares handled by merchants of every class far ahead of their actual distribution and consumption.

For example, retail shoe dealers place their orders in summer for shoes to be sold during the fall, winter, or following spring months. Wholesale shoe dealers and jobbers, similarly, order from manufacturers the particular qualities and styles of shoes indicated by the orders of the retail dealers in such quantities as the orders show to be necessary. The manufacturers, constantly receiving these orders, adjust, as closely as they can, their purchases of material, employment of operatives, and quantity of output so as to enable them to supply the quantity of shoes which have been or are likely to be ordered, their aim being, on the one hand, to meet fully and promptly the requirements of trade (in other words, the demand of the purchasing public) and, on the other hand, to avoid such overproduction as will result in a large surplus unsalable except at a loss.

The same ideas and rules prevail throughout every branch of trade commerce, and transportation, the shoe business being simply an example of other lines of business in the matter of doing things in advance.

Now, it is universally conceded that farming—agriculture—is the basic industry upon which all other industries greatly depend. The measure of the country's crops is to a large extent the measure of the country's prosperity, and the purchasing power of the people is increased or diminished as the crops are bountiful or meager. Therefore the commercial interests of the country are vitally affected by the quantity and quality of the crops; and it becomes a matter of vast importance to them to know in advance what the crop prospects are during the growing season and what the output is at harvest.

With such information carefully and scientifically gathered and compiled, and honestly disseminated, so that it can be depended upon to be as reliable as any forecast or estimate can possibly be, and relied upon as emanating from an impartial and disinterested source, the merchants and manufacturers of the country can certainly act with a degree of prudence and intelligence not possible were the information lacking.

If reports show, during the growing season, that the condition of wheat is such as to indicate a full crop on a large area the merchants of the wheat-producing sections of the country know that they can give liberal orders for goods to be handled by them several weeks or months later; the manufacturers, located far from the wheat fields, know where there will be a large demand for such of their products as are used by all dependent upon the wheat industry; the railroad companies know they will have heavy freights to transport; and so the advance knowledge regarding the probable future outcome of the crop serves as a guide to every branch of commerce and trade connected with the wheat-growing areas of the country. The same is true as to the other crops—corn, cotton, oats, rye, tobacco, etc.

If, on the other hand, the condition of growing crops is unfavorable, reliable information to that effect is equally, in fact more, important to trade and commerce than when the promise is good. For, when conditions are unfavorable, the merchants, manufacturers, and transporters must move with a degree of caution not necessary when the prospects are highly encouraging.

It was to remedy the evils and to subserve and protect the interests of all, as above noted, that Congress provided for issuing monthly crop reports, and the crop-reporting service of the Department of Agriculture aims to supply the public at large with impartial, unbiased information regarding crop areas, conditions, and yields which, it must be apparent, is highly essential and beneficial not only to farmers, but also, equally, to our commercial interests of every kind and class.—(B. Stats. C. 17.)

No other class of producers for export has as great an interest in the problems and facilities of transportation from the farm to the primary market and from that to the seacoast as the farmers have. On the basis of value, three-fifths of the exports of this country consist of the raw products of the farms and products in whole or in part manufactured therefrom; and about 56 per cent of the factory value of all manufactured products which contain more or less agricultural materials represents the proportional value of these materials.

Production and Export of Wheat.—Domestic wheat exported from the Atlantic and Gulf ports comes chiefly, if not entirely, from the States east of the Rocky Mountains. The States producing the most wheat in 1909 were North Dakota, Kansas, Minnesota, South Dakota, and Nebraska. The next States in order of production were Washington, Illinois, Indiana, and Ohio. North Dakota and Kansas combined had 14,161,757 acres in wheat, or nearly one-third of the total land planted to that crop.—(Bu. Stats. Crop Reporter, Vol.

XIII, No. 12.) In considering the quantity of wheat produced in these States the amount required for home consumption is an element to be noted. The estimated per capita consumption of wheat in the United States for the fiscal years 1902-1904, inclusive, was 6.23 bushels, including the amount required for seed.

It is in the country lying west of the Mississippi River, north of Oklahoma, and east of the Rocky Mountains that most of the surplus wheat of the United States is produced. From the fields of this region, as well as from others where the production is relatively smaller, wheat is gathered in large quantities into certain trade centers. Owing to the great quantity of flour manufactured in that city, the receipts of wheat at Minneapolis are larger than those of any other city in the United States. The receipts of wheat during the calendar year 1904 at Minneapolis amounted to 87,000,000 bushels, or 19,000,000 bushels more than were produced that year in Minnesota. At Kansas City, the second wheat center of the United States, the receipts in 1904 were 39,000,000 bushels. At Duluth, Buffalo, Chicago, and St. Louis the receipts were from 23,000,000 bushels to 27,000,000 bushels each.

A matter of importance between 1899 and 1904 was the marked increase in the receipts of wheat at Kansas City and St. Louis, the absence of any increase at Minneapolis and Chicago, and the actual decline at Duluth. It appears, therefore, that the growth in the wheat centers is taking place rather in the Southwest than in the North. The receipts of wheat flour at the leading trade centers in the interior are greatest at Minneapolis and next at Chicago, while those at Kansas City and St. Louis appear comparatively small.

Somewhat different in character from these important interior points of concentration is Buffalo. At Chicago, St. Louis, and other centers wheat is collected almost directly from the various railroad stations near the wheat fields, but at Buffalo the receipts of grain are from western trade centers, such as Chicago, Duluth, and Toledo, and the grain received at Buffalo to a large extent is forwarded to New York and other Atlantic seaports.

Corn was grown in the United States in 1909 on over 98,000,000 acres, the total crop amounting to more than 2,550,000,000 bushels.

The largest acreage in corn was found in 1909, in the States of Illinois, Iowa and Kansas, in the order named; these three States combined having an acreage in corn of 27,384,278 acres, or rather more than one-fourth of the total area planted in corn. In acreage, the ten States ranking highest in 1909 were: 1, Illinois; 2, Iowa; 3, Kansas; 4, Nebraska; 5, Missouri; 6, Oklahoma; 7, Texas; 8, Indiana; 9, Ohio; 10, Kentucky.

In production, the ten States of highest rank were: 1, Illinois; 2, Iowa; 3, Indiana; 4, Missouri; 5, Nebraska; 6, Ohio; 7, Kansas; 8, Oklahoma; 9, Kentucky; 10, Texas.

The acreage in the United States devoted to the cultivation of oats in 1909 was 35,159,127 acres. The total production of oats in that year was 1,007,129,447 bushels. The largest acreage was found in Iowa and Illinois, these two States combined having 8,831,639 acres in oats, or over one-fourth of the total land planted to that crop. In acreage the ten States ranking highest in 1909 were: 1, Iowa; 2, Illinois; 3, Minnesota; 4, Nebraska; 5, Wisconsin; 6, North Dakota; 7, Ohio; 8, Indiana; 9, South Dakota; 10, Michigan.

In production of the ten States of highest rank were: 1, Illinois; 2, Iowa; 3, Minnesota; 4, Wisconsin; 5, North Dakota; 6, Ohio; 7, Nebraska; 8, Indiana; 9, Michigan; 10, South Dakota.

The acreage planted in barley in 1909 was 7,698,028 acres. The leading States in acreage were: 1, Minnesota; 2, North Dakota; 3, California; 4, South Dakota; 5, Wisconsin.

More than three-fourths of the barley acreage of the country was in these States.

In production the leading States were: 1, Minnesota; 2, California; 3, North Dakota; 4, South Dakota; 5, Wisconsin.

As in the acreage, more than three-fourths of the number of bushels of barley in 1909 were grown in the above five States.

Potatoes in the United States in 1909 were grown to the extent of 3,668,855 acres. The total production amounted to 389,194,965 bushels. The largest acreage in potatoes was found in 1909 in New York, Michigan, Wisconsin, and Pennsylvania, in the order of rank, these four States combined having 1,312,000 acres in potatoes, or considerably over one-third of the total land planted to that crop. In acreage the ten States ranking highest for 1909 were: 1, New York; 2, Michigan; 3, Wisconsin; 4, Pennsylvania; 5, Minnesota; 6, Ohio; 7, Iowa; 8, Illinois; 9, Maine; 10, Nebraska.

In production the ten States of highest rank in 1909 were: 1, New York; 2, Michigan; 3, Wisconsin; 4, Maine; 5, Minnesota; 6, Pennsylvania; 7, Ohio; 8, Iowa; 9, Illinois; 10, Colorado.

Tobacco in 1909 had 1,294,911 acres devoted to its cultivation in the United States. The number of pounds produced was 1,055,764,806. The largest acreage in tobacco was found in Kentucky, North Carolina, and Virginia, in the order of rank, Kentucky leading with 469,795 acres, or considerably over one-third of the total acreage of the country in tobacco. These three States combined had 877,112 acres in tobacco, or nearly seven-tenths of the land planted to that crop. In acreage the ten States ranking highest were: 1, Kentucky; 2, North Carolina; 3, Virginia; 4, Ohio; 5, Tennessee; 6, Pennsylvania; 7, Wisconsin; 8, South Carolina; 9, Maryland; 10, Indiana.

In production the ten States of highest rank were: 1, Kentucky; 2, North Carolina; 3, Virginia; 4, Ohio; 5, Tennessee; 6, Wisconsin; 7, Pennsylvania; 8, Connecticut; 9, South Carolina; 10, Indiana.

(Bu. Stats. Crop Reporter V, 13; B. N. 12.)

Meat Animals Compared With Population.—Is the stock of meat animals increasing? Absolutely, yes; but, relative to population, no. These animals are not maintaining their former ratio to population as indicated by any census. The census of 1870 was so defective that it must be placed entirely out of consideration, and besides that, the South had not recovered from the civil war sufficiently to make that year a normal one. Per capita ratios of cattle, sheep, and swine on farms and ranges, not including calves and lambs under 1 year, have been computed for each of the three classes named and for each of the seven national censuses. Leaving out of the question the census of 1870 as unworthy of consideration, it appears that the ratio of cattle to population since 1840 was lowest in 1900, although highest in 1890, which was in the great range period. With regard to sheep the lowest ratio was in 1900, when it was less than one-half the ratio of 1840 and but little more than half the ratio of 1850. The swine ratio to population was lowest in 1900 and presents an unbroken decline from 1840, 1870 being out of consideration.

Number of Cattle, Sheep, and Swine on Farms and Ranges, Per Capita, 1840-1900; Not Including Calves and Lambs Under One Year.

Census of June 1—	Cattle.	Sheep.	Swine.
1840	0.88	1.13	1.54
1850	.77	.94	1.31
1860	.81	.71	1.07
1870	62	.74	.65
1880	.79	.84	.99
1890	.92	.65	.92
1900	.69	.52	.83

Imports of Farm and Forest Products, 1907-1909.—The value of farm products imported into the United States during the year ending June 30, 1909, amounted to $639,000,000, an increase of $99,000,000 over the previous year and $12,000,000 more than in 1907. The value of all merchandise imported in 1909 was $1,312,000,000, an increase of $118,000,000 as compared with 1908, and a decrease of $123,000,000 compared with 1907; the imports of farm products formed such a large proportion of the total imports as to show a percentage for the three years, respectively, of 43.7, 45.2, and 48.7 per cent.

The imports of forest products in 1909 exceeded in value those of each previous year and were valued at $124,000,000, an increase over the previous year of $26,000,000 and $1,500,000 more than in 1907. Of the enormous increase over 1908, $25,000,000 was due to india rubber, the article that caused more than 90 per cent of the big decline in the total of 1908 from that of 1907.

The grand divisions as sources of imports of farm products into the United States in each of the years 1909, 1908 and 1907, named in the order of their importance as judged by value were: Europe, North America, Asia, South America, Oceania, and Africa. In the order of their importance as sources of imports of forest products in 1909, they were: North America, South America, Europe, Asia, Oceania, and Africa. The relative rank of the grand divisions as sources of imports of farm and forest products was the same for 1907 and 1908 as for 1909 with one exception. North America ranked second as a source of imports of forest products in 1907, but rose to first place in 1908 and 1909. Each of the grand divisions, with one exception, Africa, shows an increase as a source of imports of farm products in 1909 as compared with 1908.

Farm products valued at $214,000,000, or nearly one-third of the total farm products imported, came from Europe, $152,000,000 from North America, $135,000,000 from Asia, and $137,000,000 from the other three grand divisions. The largest increase in value in 1909 over the preceding year was in imports from Europe; farm products from this grand division amounted to $177,000,000 in 1908, and $214,000,000 in 1909, which was $10,000,000 more than in 1907.

In imports of forest products South America, compared with other grand divisions, showed the greatest decline in 1908 and the greatest increase in 1909, both of which were due to india rubber.

In each of the three years mentioned the imports from Cuba exceeded those from any other country. In 1908 the imports from that country were $75,000,000, which was $14,000,000 less than in 1907, and in 1909 they were $89,000,000, which was $15,000,000 more than in 1908, the variations being due principally to shipments of sugar. Other countries showing large increases in 1909 over 1908 were as follows: United Kingdom, $20,000,000; Argentina, $11,000,000; Brazil, $9,000,000; Dutch East Indies, $9,000,000; France, $6,000,000; Chinese Empire and Italy, each $5,000,000; other countries having an increase of more than $4,000,000 were British India and Japan.

Imports of forest products in 1909 were valued at $124,000,000; of this amount $80,000,000, or nearly two-thirds, came from three countries, Brazil, Canada, and the United Kingdom. Brazil occupied first place in 1907, fell to second place in 1908, and rose to first place in 1909—these changes being due to imports of india rubber from that country. Other countries showing increases which were due principally to the same article were the United Kingdom, $7,000,000; Germany and Mexico, each with increases of more than $1,000,000.

The aggregate value of the six principal groups of farm products imported in 1909 was $437,000,000, as compared with $353,000,000 in 1908 and $443,000,000 in 1907. The value of the leading groups in 1909 was nearly $98,000,000 for sugar and molasses, $92,000,000 for packing-house products, $80,000,000 for silk, $79,000,000 for coffee, $45,000,000 for wool, and $43,000,000 for vegetable fibers, chiefly cotton, sisal, manila, and jute. Other important imports in 1909 were tobacco, $25,000,000; alcoholic liquors, $23,000,000; and fruits, $22,000,000, of which bananas were valued at $11,000,000. The principal groups of imports of forest products were india rubber, $62,000,000; lumber, $21,000,000; and wood pulp, $9,000,000.

Shipments of farm products to the United States from its island possessions and Alaska in 1909 were valued at $71,000,000, a decrease of $2,500,000 compared with 1908 and an increase of $13,000,000 compared with 1907. In 1908 and 1909 sugar from Hawaii formed more than 50 per cent of the total shipments of farm products from all noncontiguous possessions. In 1909 the value of the sugar sent to the United States from these possessions was $58,000,000, manila fiber $7,000,000, fruit $2,500,000, and tobacco $1,000,000.

Shipments of forest products to the United States from its noncontiguous possessions in 1909 were valued at $118,000, more than half of which represented gums and lumber from the Philippine Islands. The shipments of timber from Hawaii were valued at $45,000.—(Bu. Stats. B. 82.)

Exports of Farm Products 1851-1908.—The value of exports of domestic farm products from the United States increased from an average of $150,000,000 in 1851-1855 to $875,000,000 in 1901-1905. The largest exports were in 1907, amounting to $1,054,000,000, and the lowest in 1865, when the amount was only $85,000,000. The value of exports of domestic merchandise other than farm products has increased even more rapidly, as is shown by the relative importance of farm products in the total exports. During 1851-1855 farm products constituted four-fifths of the total exports and in 1901-1905 only three-fifths.

Exports of foreign merchandise are relatively unimportant as compared with those of domestic merchandise. The total exports of the former class in 1908 were only $26,000,000, of which $10,000,000 were farm products.

Contrary to the tendency shown in domestic exports, the relative importance of farm products in the imports has increased during the last half century. In 1851-1855 farm products constituted 28 per cent of the total merchandise imported, and in 1901-1905 47 per cent; 51.5 per cent, for the highest five-year period, was reached in 1876-1880 and in 1891-1895.

From 1851 to 1897, inclusive, the domestic farm products exported exceeded in value those imported except in 1864 and 1865, and the exports of domestic merchandise other than farm products in each of these forty-seven years was less in value than the imports.

Beginning with 1898 each of these two classes of merchandise has in each year shown a balance in favor of exports, with the exception of 1903, when merchandise other than farm products was imported more largely than exported. The excess of exports of farm products in each of twenty-three years during the fifty-eight years was sufficient to overcome an excess of imports in the trade in other merchandise. The largest excess in exports over imports of all merchandise was $666,000,000 in 1908, and the next largest was $665,000,000 in 1901.

The average annual values of domestic agricultural products exported from the United States during the five years, 1901 to 1905, inclusive, were for each man, woman and child in this country during that period (i. e., the per capita values) as follows: Cotton, $4.17; wheat, including flour, $1.63; canned, cured, and fresh pork, $0.82; lard, $0.61; corn, $0.54; canned, cured, and fresh beef, $0.46; live cattle, $0.45; tobacco, $0.37; cotton-seed oil, $0.17; cotton-seed oil cake and oil-cake meal, $0.15; oleo oil, $0.15; oats, $0.05; and all other products, $1.32; making a total of $10.88 per capita. The corresponding total for 1851-1855 was $5.85, which was made up as follows: Cotton, $3.84; wheat and wheat flour, $0.76; tobacco, $0.43; pork, $0.26; lard, $0.15; corn, $0.14; beef, $0.08; and other articles, $0.19.

The per capita value of cattle exported in 1901-1905 is one hundred times as great as in 1851-1855. Products not separately recorded so early, in which a heavy export trade sprang up within the period covered by this bulletin, are oleo oil, cotton-seed oil, and cotton-seed oil cake and oil-cake meal. The value for tobacco showed a decrease. There were also increases in beef, pork, lard, corn, wheat (including flour), and cotton.

Among the prominent commodities, the per capita exports of which increased tenfold or more in quantity from 1851-1855 to 1901-1905, were cattle, oleo oil, oats, cotton-seed oil, and cotton-seed oil cake and meal. In the first five-year period the number of cattle exported averaged per annum one animal for every 20,000 population of the United States, and in 1901-1905 one animal for every 167 population, or, on the basis of 100,000 population, an average of 5 head during the first period and 600 head during the last.

The figures for the other items just mentioned were not available for 1851-1855, but the increase for the time given and the presumption that in the earlier period the exports were very small, if any, entitle those items to be classed with those whose quantity increased at least ten times in the period.

Prominent articles, the per capita exports of which increased in quantity less than tenfold, but at least fivefold, include beef, pork, lard, and corn.

The per capita exports of wheat, including flour, and of cotton increased less than fivefold in quantity. In 1851-1855 the average annual exports of wheat per capita were 0.6 bushel and in 1901-1905, 2 bushels. Of the 11 five-year periods from 1851 to 1905 continuously the per capita exports of cotton were more than 40 pounds per annum. In 1861-1865 the exports fell to 2.1 pounds per capita, but from that period each successive five-year average showed an increase over the preceding one. In 1891-1895 the average for 1851-1855 was exceeded. The highest five-year average for the quantity of cotton exported per capita was in 1856-1860, when it reached 44.8 pounds. The exports of tobacco per capita decreased from an annual average of 5.3 pounds in 1851-1855 to 4.1 pounds in 1901-1905.

Comparing 1896-1900 with 1901-1905, the quantity exported per capita of the following prominent products showed decreases in the latter period: Beef, pork, lard, corn, oats, wheat (including flour), cotton-seed oil, and tobacco. Among the products whose corresponding averages showed increases in 1901-1905 over the preceding five-year averages were cattle, oleo oil, cotton, and cotton-seed oil cake and meal.

Fruits have recently become an important element in the export trade, their value in 1908 being $12,000,000 and in 1851 only

$71,000. The principal fruits exported in 1908, in order of value, were fresh apples, dried apples, prunes, and oranges. The largest exports of fruit were in 1904, when they amounted to $20,000,000, of which fresh apples, prunes, dried apples, and oranges made more than $12,000,000.

Exports of hops have fluctuated widely. The exports in 1855 were 4,000,000 pounds; in 1860, 300,000; 1861, 8,800,000; 1866, 350,000; 1870, 16,000,000; 1874, 100,000; 1878, 18,000,000; 1887, 260,000; 1889, 13,000,000; 1899, 21,000,000; 1903, 8,000,000; and 1908, the largest on record, 23,000,000 pounds.

From 1851 to 1861, inclusive, exports of rice ranged from 39,000,000 to 82,000,000 pounds a year, but from 1871 to 1899, inclusive, there were only two years in which the exports exceeded 1,000,000 pounds. In 1900 they reached 13,000,000 pounds, but in 1901 dropped back to only 1,100,000 and in 1902 to 600,000 pounds. The abnormal exports of 1905—75,000,000 pounds—were followed in 1906 by 4,000,000 pounds, and in 1907 and 1908 by successively smaller exports.—(Bu. Stats. B. 75.)

The principal countries to which meat animals are exported from the United States with values of animals exported in 1906 are: United Kingdom ($38,222,472), Cuba ($2,023,876), Canada ($1,071,854), and Belgium ($918,620). The principal countries to which meat and other packing house products are exported from the United States with values in 1906 are: United Kingdom ($112,713,772), Germany ($30,066,997), Netherlands ($19,793,818), Belgium ($8,203,000), and Cuba ($5,754,738).—(Bu. Stats. B. 55.)

Europe Consumes More Meat Than It Produces.—The United Kingdom of Great Britain and Ireland is not only the greatest industrial but also the greatest meat-eating country of Europe. It is not surprising, therefore, to find that the imports of meat animals, meats, and other packing-house products into the United Kingdom are enormous, reaching the total sum of almost $300,000,000 per annum, and the imports of these products are rapidly growing. Imported meat finds a better market in the United Kingdom than in any other European country. Certain live animals are forbidden to be brought from foreign countries, as cattle from Argentina and swine from the United States, but the importation of meat is encouraged. By far the greater part of the meat imported into Europe comes from three regions. The most important includes that part of the United States east of the Rocky Mountains and that part of the Province of Ontario, Canada, lying east of Lake Huron; the second in importance is situated along the River Plata and lies almost wholly in Argentina; and the third great surplus region is New Zealand and Australia. The leading meat products of the United States and Canada are cured pork, lard, and fresh beef; Argentina supplies fresh beef and fresh mutton; and the leading product of Australasia is frozen mutton.—(Bu. Stats. B. 40.)

Russia being primarily an agricultural country with an enormous export of grain, and the Russian people consuming very small quantities of meats, the imports of meat animals and packing-house products are very small and do not show any strong tendency to increase.

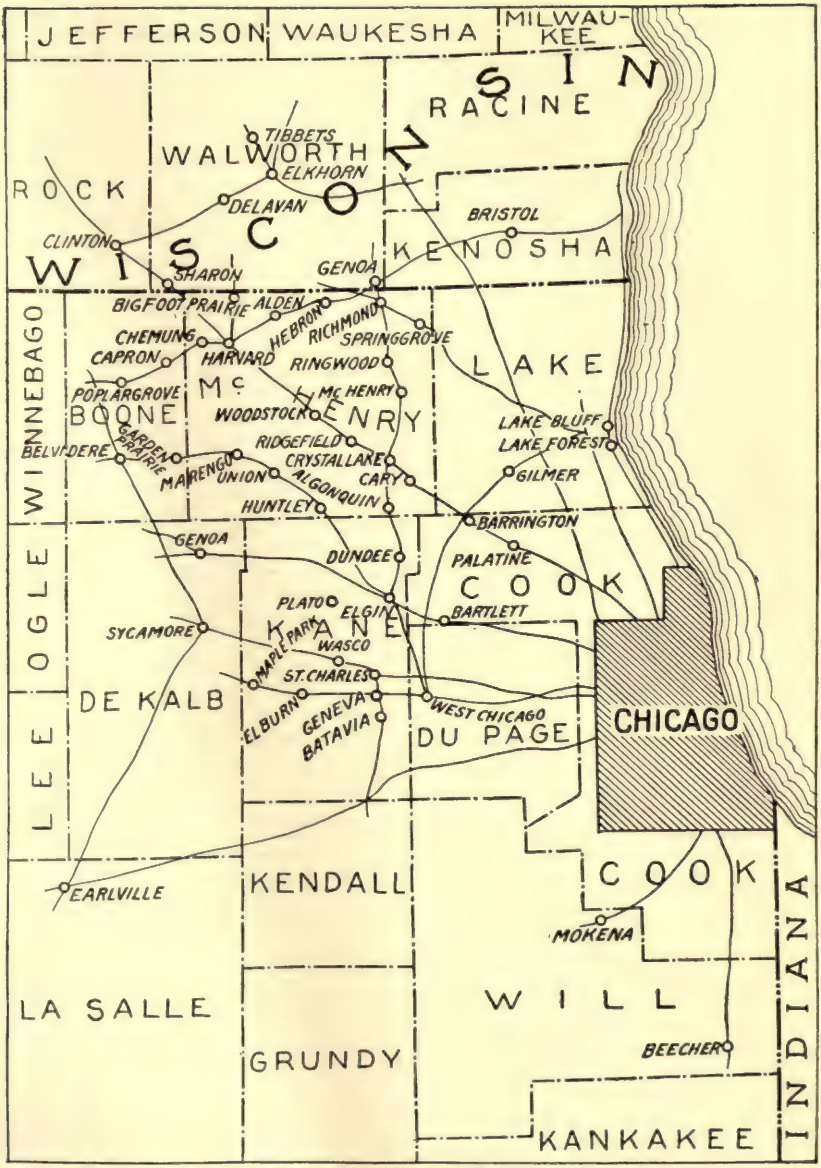
The main articles of imports are cattle (annual average for the three years, 1901-3, $954,000); sheep and goats (annual average, $997,000); and animal fats ($1,838,000). Asia is the main source of the live animals imported. On the other hand, the packing-house products come in mainly across the European frontier, the United Kingdom supplying 59.2 per cent, evidently re-exports, while Germany contributed 17.7 per cent. Animal fats constituted the main packing-house product, equaling 80.9 per cent of all the packing-house products during 1901-1903. About three-fourths of the fats came from the United Kingdom and one-eighth from Germany. The direct share of the United States in this trade is very insignificant. The average imports from the United States in 1901-1903 were $130,000. The only products the imports of which from this country are of importance are the animal fats, and of all of these products imported into Russia the share of the United States was only 6.1 per cent in 1901-1903.—(Bu. Stats. B. 41.)

In Canada, owing to the cold climate the livestock industry is confined to farms chiefly; for the animals require shelter during the winter, and keeping large herds on open ranges throughout the year is generally not practicable. Most of the live stock of the Dominion is in the region lying east of Lake Huron. Of the 5,600,000 cattle in the country in 1901, all but 1,000,000 were in Ontario, Quebec, and the Maritime Provinces, and in Ontario alone there were 2,500,000. The number in this Province increased to 2,800,000 in 1904. The census for 1901 reported 2,400,000 swine in the Dominion, of which 2,100,000 were east of Lake Huron and 1,600,000 were in Ontario. In 1904 there were 1,900,000 swine in Ontario.

Of the live meat animals exported from Canada, the most important are cattle. The exports of cattle in 1904 were valued at $10,000,000, an increase of $3,000,000 in 10 years. The value of exported sheep experienced no marked increase or decrease during the years 1895-1904, and the exports of swine, although much larger than in earlier years, were relatively unimportant during 1902-1904.

A large number of Canadian cattle are exported by way of the United States ports. During the year ending June 30, 1904, more than 40,000 Canadian cattle passed through United States ports on their way to foreign countries. According to the report of the Canadian minister of agriculture for 1902 the Canadian exporter of cattle was at a disadvantage as compared with his United States competitor. Freight charges on cattle in Canada were said to be higher than in the United States, and the United States cattle were gentler and more easily handled in cars and on shipboard, and hence were delivered in better condition to the British buyers than were the wilder cattle of western Canada.

Bacon is the most valuable of the packing-house products exported from Canada. Its value in 1904 was nearly $13,000,000, and in 1903 it exceeded $15,000,000. All other packing-house products



MAP SHOWING LOCATION OF MILK-BOTTLING PLANTS SUPPLYING CHICAGO.
DEPT. OF AGR.

together were valued in 1904 at $4,000,000 and in 1903 at $2,000,000.—(Bu. Stats. B. 39.)

Of the influences which during the last half century or more have affected the cost of marketing live stock, some of the most important were those relating to their transportation. The cost of transportation includes not only charges for freight, feed, attendance, yardage, and other expenses of the road, but also losses in transit and other items involving more or less directly the expenditure of money, labor, and time in moving meat animals from their native farms or ranges to places of slaughter.

The growth of economy in the transportation of meat animals has taken place along at least three general lines. One is the saving to the railroads and steamships handling the traffic, which phase of improvement is reflected in lower freight rates. The size and efficiency of cars and vessels have been increased and cheaper methods have been devised for handling traffic in stock yards. A second phase is the reduction of loss in transit, a saving which may be credited to mechanical improvements, to legal regulations, and to the change over a large number of routes whereby the freight charge depends upon the weight of the live stock shipped and not upon the number of cars used. The third direction of this growth of saving is found in the tendency to transport meat instead of live animals. This movement is illustrated by the establishment of new slaughtering centers nearer the sources of supply than are the older meat-packing cities east of the Missouri river.—(Agr. Dept. Y. B. 1908.)

Cause of Increased Values.—Farm real estate in the United States has gained in value in such a degree since the census of 1900 that an examination of the causes of this gain may be not only interesting, but instructive, to the economic student as well as to the practical agriculturist.—(Bu. Stats. B. 44.)

With the new economic conditions of agriculture in view and suspecting large effects upon land values, an investigation of changes in these values since the census of 1900 was undertaken in September, 1905. A schedule was prepared and sent to about 45,000 crop correspondents of the Bureau of Statistics, some of them representing counties, others parts of counties, and still others townships.—(Bu. Stats. B. 43.) In response to this request many statements were received from all parts of the United States showing the local conditions which affect farm values.

From every agricultural neighborhood in the United States explanations have been received of the increases and decreases in the real estate value per acre of medium farms during the period. Subject to some qualifications, the general principle is that the farm land itself has become more highly capitalized by a larger amount of net profit per acre. Only the main features of the analysis can be given in this article.

In the general matter of price of farm products farming had long been performed under disadvantages that were often discouraging until a few years ago. With now and then a year of exception in favor of this or the other crop it has been a general fact that prices of farm products, long previous to these recent years, have fallen too near the full economic cost of production, which is considerably larger than the immediate cost of production and includes many items generally overlooked by farmers. Indeed, it is quite certain that the price has at times fallen below the full economic cost of production, of which the most conspicuous illustration was afforded some years ago, when the price of cotton fell to 4½ cents per pound, or even lower, at the plantation. At the end of the five-year period covered by this investigation, the prices of farm products had risen out of the depths to which various causes had previously sunk them, so that the farmer is at last getting a fair net return for his labor and farming operations in most products. This is naturally reflected in the higher capitalization of agricultural land. This conclusion is not advanced theoretically, but is amply sustained by the reports of many thousands of correspondents in all parts of the country and for all classes of farms for which there has been a considerable increase in price of products.

One can well realize how directly the availability of cheap public land suitable for farming has depressed the value of old agricultural land and kept from rising to its otherwise natural level the value of the newer land taken into cultivation, upon reading the statements of many correspondents, particularly in the agricultural margin near the land recently acquired from nation, state, or railroad. The national land that can be utilized agriculturally is now reduced to about 300,000,000 acres, but nearly all of this is suitable only for grazing, since it can not be used in dry farming nor under irrigation.

Much cultivable land, however, especially in the Southwest, has passed into private ownership during the five years under review, and there is striking testimony from many correspondents that until it passed into private ownership it held down the value of the acquired farms in near-by regions. This effect has extended backward upon the farms farther and farther away, even to the Atlantic coast, where the direct cause has not been as apparent as in the neighborhood where its effect is closely associated with it.

While the public land suitable for farming has been reaching exhaustion the flow of immigration from foreign countries and from the older parts of this country has been continuing in its direction, and where no farming land could be obtained from nation, state, or railroad the influx of agricultural people was halted in regions where farms had been established in more recent years, and the consequent pressure of new demand upon a fixed area increased the value per acre often as much as 50 to 100 per cent.

Along with the general causes that have elevated the price of farm land should be mentioned the diminishing rate of interest. So great in the aggregate have been the savings of the farmers and persons in other occupations in the north central states and in other sections that a large amount of these savings has sought investment in farms, even to the extent of raising farm values and diminishing the rate of interest, so that an advance of the price has followed often with no increased net profit per acre.

In the cotton belt the abolition of the crop lien in consequence of profitable prices of cotton has worked a greater economic revolution than has taken place in any other part of the country or for any crop other than cotton. When the cotton planter ceased to pay an extremely high rate of interest for an advancement of supplies—estimated at 40 per cent in 1890—and became able to sustain his plantation with his own capital, as he did in 1902, and was often able to retain a large portion of his cotton for sale at a time when most to his own advantage, his land was at once converted into an economic stronghold and appreciated in value in a greater degree than the land devoted to any other large crop.

In the North Atlantic states, and in a less degree in other groups, there has been some back pressure upon the land from the cities, and in this reversion of the tide of population from country to city the old farm lands have not been lost to agriculture, although, in so far as they have become the diversion of wealthy men, they may have become unprofitable. In some regions the old abandoned farms are becoming the country homes of city families, and are passing back into some sort of cultivation and production.

Effect of Better Farming.—It would by no means be fair in the explanation of increase of farm values during the period to confine it to increases in price of products and to pressure of demand upon area. Very large effects have been derived from better cultural methods; from the substitution of profitable for unprofitable crops; by the adoption of more intensive culture and crop; by better applied labor; by larger and cheaper facilities for reaching markets; and by some improvements in the business features of marketing products. Each one of these causes is of large account and all together combine to make the net return per acre larger than it was in 1900 by an amount sufficient to raise the capitalization of farm lands in a considerable degree.

The values embraced in this investigation include improved and new buildings and all improvements upon farms. In many cases correspondents have reported a large percentage of increase in farm values per acre where the increase was almost entirely due to added improvements in the way of better dwellings, new barns, improvements in old barns, new granaries, and new buildings for the protection of live stock in winter.

Throughout extensive areas there have been great additions to land values as the result of draining by tile and open ditches, and the latter are sometimes so large as to be called canals. Increases have resulted from the removal of the stumps of forest trees and the construction of new or better boundary fences. Better and more durable roads on the farm and between the farm and its market town or railroad station have had a distinct effect upon the farm values.

Along with numerous improvements, not all of which can be mentioned here, stands forth the improvement of the soil itself. There is a materially increased production of live stock, with the resultant increased acreage of forage and grain crops which in rotation produce farm manures, humus, and rest; enrich the soil, as with nitrogen brought by legumes; and improve the mechanical condition of the soil for all crops. In regions needing commercial fertilizers, nitrogen, phosphorus, potash, and lime have been used more abundantly and more intelligently, and on crops bringing better prices.

A matter of great importance in its bearing upon the increased value of farm lands is the new economic independence of farmers, fundamentally growing out of their improved financial condition. Farmers now occupy a strong economic position, founded upon the tendency of the consumption of some important products to increase faster than population does, and upon the tendency of the desires for these products to increase faster than the production does, so that with respect to these products consumption is close upon the heels of production.

Poultry.—It may seem a matter of small consequence to mention poultry and eggs as an instance, but it should be remembered that the values of these products now reach an annual figure of half a billion dollars or more, or an amount about equal to the value of the wheat crop. The price of eggs has been high and growing higher for several years, because consumers have wanted more eggs than have been produced. The exports are not worth mentioning. Apparently there is no limit to the consumption of fresh eggs at a moderate price.

Fruit.—There is not enough fruit of any kind raised in this country at the present time which is actually placed upon the market in the grade of first quality, or better, that is produced in sufficient quantity to meet the wants of consumers at a moderate price. The city family that has bought first-grade apples in almost any recent year has paid a luxury price. This is true also of pears, plums, peaches, and oranges, and it is true of the small fruits, such as cherries and grapes. The assertion may easily be extended to most, if not all, of the commercial berries—strawberries, currants, blackberries, and raspberries.

Butter.—We have no larger butter exports from this country because the price of first-grade butter is often lower in London than in New York. The highest priced butter in the world in its home markets, taking first and fancy grades and ignoring specialties in other countries too small for notice, is found in this country. With regard to milk and cheese also the economic position has become stronger.

The annual products of dairying, of fruit and vegetable raising, and of poultry keeping aggregated three-tenths of the gross value of all farm products in 1905, and these particular products belong to the class of those for which there is a tendency of demand to be greater than supply. In the case of none of these products is there a desired quantity satisfactory in quality obtainable by consumers at moderate prices. The public is underfed in the higher grades of these luxuries of the farm.

Meat Animals.—These are establishing themselves in a stronger position in favor of the farmer, because of the tendency of population increase to outfoot the increase of these animals; but this statement, although true under natural conditions, may be done away with in its application to this country by the prohibitive legislation of importing countries.

Wheat.—In this also the farmers of this country are in a position that is at least moderately strong. Canada and Argentina may stand in the way of a more advantageous position for a dozen years or so, but in the meantime the increasing demand of the world for wheat promises to the wheat grower that he shall not again suffer from the consequences of overproduction.

The foregoing lines of evidence converge upon the conclusion, which is now apparent in all parts of the United States, that in his new economic independence the farmer is now more than ever before free to choose his crop, and this is a matter of tremendous importance. This removes obstacles to the rotation of crops and to intensifying culture and methods. It gives the farmer ability to raise leguminous crops, with their important benefits to the soil. It enables him to multiply his domestic animals, with further consequences upon tillage and land fertility. It enables him to adapt himself to his best markets with the best crops. The agricultural situation just indicated is very appreciably reflected by increased land and improvement values.—(Bu. Stats. B. 44.)

PART II

SPECIAL FARM TOPICS.

INTENSIVE FARMING.

EVERY farmer who grows 100 bushels of corn, 40 bushels of wheat or three tons of hay to the acre is doing intensive farming. Also, the man who makes every part of his land produce, either directly or indirectly, is an intensive farmer, if he makes it produce to its utmost in quantity and quality. There are two classes of farmers—the indifferent farmer who is content with little, and the intensive farmer who demands much.

Strangely enough, farming, the first of all industries, has been the last to break away from dull plodding and blind drudgery, and to share in the benefits of intelligent understanding. Until the present generation, the farmer has never known what he was doing, nor why he did it. How bitter has been the tragedy of this long groping in the dark by the man who has not only eaten his own bread, but fed the world by the sweat of his over-burdened body. To the unthinking, life is but endless toil and drudgery, while pleasure and inspiration come to the man who understands his work.—(Univ. Ill. B. 143.)

Intensive farming includes the selection of the crop that will give the best return. This largely depends upon soil, climatic conditions and proximity to market. The following table gives an illustration of proper crop selection. It is a table of the actual results of intelligent and intensive methods applied to nearly five acres of ground:

Crop.	Acreage.	Marketable crop.	Gross receipts.	Cash expenditures.	Net cash returns.	Days labor.		
						Men.	Women and boys.	Team.
White Bermuda onions	.47	3916 lb.	$ 73.24	$ 8.94	$ 64.30	31.5	.5	1
Early Rose potatoes	.84	2615 "	70.00	12.85	57.15	42		4.5
Dwarf tomatoes	.52	13531 "	624.60	72.72	551.88	85	38	10
Rockyford cantaloupes	1.00	780 doz.	144.60	9.00	135.60	31	8	2
Watermelons	.20		15.65	2.00	13.65	3		
Alfalfa	1.70	20 tons*		22.41		14		9
Totals	4.73		$928.09	$127.92	$800.17 **	206.5	46.5	26.5

*Value $120 fed to team.

**Deducting cost of alfalfa.

—(F. B. 63.)

From this statement it is seen that from less than five acres of ground, at a cash outlay of $127.92, a net revenue of $800.17 was obtained. Of the cash outlay $22.41 was for alfalfa raised on the farm and fed. On a little more than half an acre, with 123 days labor and 10 days team labor, a gross revenue of $624.60 resulted. The same intensive methods were applied to the cultivation of the onions, potatoes and melons as to the tomatoes, yet the cash return from the tomatoes was more than double those from all the others.

By means of contrast with the above results there follows the returns from a typical barley crop grown in the same neighborhood the same year. The crop was from 110 acres. The amount of the crop was 2,479 sacks or 138.8 tons of grain and 7 tons of barley hay. The figures as follows were furnished by the owner:

	Outlay.	Returns.
Sowing	$ 361.64	
Heading	438.05	
Threshing	867.64	
Hauling to market	328.86	
Rolling and storage	374.14	
Amount received for barley		$3,531.32
7 tons of hay credited at $6		42.00
Owner's personal labor credited at		140.00
Net returns	1,342.99	
	$ 3,713.32	$ 3,713.32

That is to say, this barley, not charging the owner's labor against the crop, gave a return of $1,342.99, or $12.21 an acre. It was not possible in this case, as it is with a small, intensively cultivated place, to manage the labor within a family, and in this instance cash and credit to the amount of $2,370.33 was required to carry the crop through.—(F. B. 63.)

All the experiments made at the various experiment stations are along the lines of intensive farming. The stooling of wheat planted at varying distances apart is shown as follows:

1. The number of mature heads produced by each seed of wheat, oats, or barley varies greatly with the locality, season, and distance apart seeds are planted.
2. The number of heads and the amount of grain produced by each seed increases rapidly with the greater amount of room accorded each.
3. When planted wide distances apart the straw is shorter than when thickly planted but, on account of the greater number of adventitious stems produced and the larger and more numerous leaves, there is more straw in proportion to the amount of grain where there is plenty of room.
4. Where given too much room many more stems are produced than will mature heads. On account of the continuous growth from the crown of the stool during the summer the grain is late in maturing, does not fill well, and, as a whole, produces light, inferior grain.

5. Larger heads are produced upon grain planted more than one inch apart though all the heads may not be as uniform in size. The number of seeds in the largest heads produced increases rapidly with increased distances between plants.

6. While more grain will be produced by each seed when planted at greater distances than one inch apart the actual amount of grain will be less for the area of land used. Therefore seeding so thinly that there will be less than one plant for each inch of drill row decreases the amount of grain per acre rather than increases it. —(Univ. Ill. B. 37.)

The application of intensive methods to the cultivation of potatoes will readily increase the production 100 per cent. On the average it costs about $15.25 per acre to plant and cultivate potatoes. It costs no more to seed and cultivate where a crop of 350 bushels is produced than where only 200 bushels are harvested, the difference being in the methods pursued. The following table gives the actual results on a 40-acre farm intensively cultivated, where potatoes furnished the principal crop:

Sales, Expenses, and Net Income of Farm in 1906.

Sales.	Value.	Expenses.	Cost.
3½ tons hay	$ 25.00	1 cow	$50 00
Potatoes, 2,000 bushels at 60 cents	1,200.00	257 bushels corn	94.45
4 cows	185.00	16 bushels wheat for poultry	8.60
1 calf	15.00	Oil, meal, and bran	10.00
4½ bulls[a]	257.50	Labor	68.00
1 colt	70.00	Seed Potatoes	[b]90.00
Poultry	[b]100.00	Pasture	[b]15.00
Eggs	[b]30.00	Miscellaneous	[b]75.00
Strawberries	60.00	Taxes	[b]25.00
Total	1,942.50	Total	436.05

[a] This item includes a half interest in 1 bull. [b] Estimates.

Summary:

Value of farm, 40 acres at $200	$8,000.00
Value of live stock	1,280.00
Value of machinery and implements	484.00
Total	9,764.00
Sales	1,942.50
Expenses	436.05
Net income of farm	1 506.45

—(F. B. 325.)

The net income derived is 15.4 per cent on $9,764, the total value of the farm and equipment. The figures do not give anything for the labor of the owner. This should be given to get the correct net profit. Rotating with grass has been found excellent in increasing the yield of potatoes. Under intensive methods the land is kept busy.

Fertilization and rotation are important factors in intensive farming. The fertilizer used must meet the requirements of the soil and of the crop proposed to be cultivated. Rotation must depend largely on climate as well as character of the principal revenue crop.

In those sections largely devoted to the raising of potatoes a carefully planned system of rotation is followed. As a rule in those sections potatoes are grown only one year, followed by oats or wheat, with which are sown clover and timothy for hay. The hay crop is cut one year and the ground plowed in the fall for a new potato crop. With potatoes frequent cultivation is the keynote to success. Fourteen cultivations have been known to produce 140 barrels to the acre, while an adjoining field similar in condition and soil produced only 70 barrels with two cultivations.—(F. B. 365.)

Careful selection of the seed, systematic spraying and frequent cultivation are essentials in intensive cultivation of potatoes. Green manure as a fertilizer has been the most successful.—(F. B. 365.)

Intensive Farming Applied to the Dairy.—One of the biggest national problems which is receiving attention today, is the conservation of natural resources. No one doubts the importance or timeliness of this great question. But a still larger problem to consider is the saving of human energy, for there is much waste of human lives in weary, unprofitable toil. To many a dairyman this conservation means that he could increase his profits tenfold, as others have done, without running down the land or robbing some other farm, by simply putting intelligence into his business, and thus win for himself and family the opportunity for greater comfort, development, and useful service to humanity.

Why is the average annual production of the cows in the United States only 150 pounds of butter fat, causing a loss of $1.40 to the owner, instead of 325 pounds of butter fat, making a profit of $40.40 annually—the point to which dairymen have increased their grade herds by simply putting intelligence into the business, and this is by no means the maximum of what can be done. There is no reason why all of the herds in the United States should not be yielding as large an annual production as these, if they were as intelligently handled. Dairymen do not stop to consider the tremendous trifles in their business. While the difference in earning power of these cows is only 11½ cents per day, this small increase for each of the 18,000,000 cows in the United States would mean an additional profit of $757,000,000 annually for the dairymen.

The fundamental principle on which all agriculture is based is: "How much of a given product can be permanently obtained from an acre of land, and at what profit?" From this fundamental, basal standpoint, the dairyman's problem is: "How much milk and butter fat can be obtained per acre of land, and at what gain?"

Wherever intensive dairying has been discussed, it has usually taken the form of keeping a cow to an acre of land. What is the meaning of a cow per acre? Absolutely nothing. This brings us again to the same old misunderstood problem over which dairymen have blundered. Many think that a cow is a cow, and that ends it. There have been cows at the University of Illinois, purchased from the dairy herds of the state, one of which produced ten times as much milk and nine times as much fat as another in a year. As was stated before, a cow per acre means nothing, and has nothing to do with it. The object is to show the possibilities in milk production. It is much too early to draw definite conclusions, as it will require the average of several years to obtain results from which such conclusions can be drawn, but the present indications are that if every acre of the farm is made to produce a good crop every year, and this crop be well harvested and saved in good condition and fed to the dairy herd, every individual of which is a good, economical producer, it would multiply the present profits in milk production on our dairy farms about five times as it is well known that the combined results of good tillage, good seed, good crops, well harvested and saved and intelligently fed to efficient dairy cows, are astonishingly great.—(Univ. Ill. B. 143.)

Intensive dairy farming considers the economy used as well as the conservation of energy and labor. Many farmers maintain only a few cows, and it is as important for them to apply the most modern methods to the feeding and care of the small herd as it is for the great dairy farmer. It costs as much to feed a cow which gives only a small quantity of milk as it does the one which gives three or four times as much. So it is a matter of economy as well as of profit to keep only first class dairy cattle. The high grade of the herd should be maintained by carefully eliminating the poor milkers and replacing them by first class stock. Correct feeding is another very important factor in making the dairy cows pay.

A good flow of milk can be obtained from feeding simply corn stover, clover hay, and the bran from corn and wheat, together with some straw. On a feeding experiment, several cows produced as high as 40 pounds of milk per day for 50 days, on corn silage, alfalfa hay, and straw, and there is no question but that this is an economical method of milk production.—(Univ. Ill. B. 143.)

The crops raised on dairy farms are of the greatest importance. Corn and alfalfa are the two crops returning by far the most digestible nutrients per acre. The corn should be put in the silo and the alfalfa made into hay. They make a balanced ration without the addition of high priced purchased feeds, resulting in a great saving over the common method of feeding on the dairy farms. One farmer in Illinois had 8 cows on an official test that produced 136,715 pounds of milk, or an average of 17,089 pounds per cow. If this milk had been sold at wholesale on the Chicago market it would have brought $2,187. Sold, as it was, at 7 cents per quart, it brought $570 per cow, or a total of $4,558—not at all bad as an income from only eight cows, and their calves are not the kind that are given away at the present time.—(Univ. Ill. B. 143.)

Intensive Farming Applied to Fruit.—The usual aim of the fruit grower as well as the farmer is to produce large quantities of salable produce with the least amount of labor and invested capital. In many cases, especially in opening up new countries, extensive methods were probably the most profitable at the outset. In extensive farming nature is depended upon to do the greater part;

man does comparatively little. In intensive methods the opposite is attempted; nature is assisted in every possible way and encouraged to do her utmost, the aim being the production of the largest quantities and of the finest quality per acre. As year after year the country becomes more thickly settled, land becomes scarcer and more valuable and intensive methods must gain prominence. Even now certain individuals are criticized for attempting to farm too much land—more than they can handle profitably.—(Y. B. 1904.)

There is no crop to which the application of intensive methods of cultivation can be better applied than to that of the orchard. The demand for fruit is constantly on the increase, and prices are always remunerative. One of the principal methods goes to the care of the orchard and the judicious use of a cover crop. An orchard cover crop checks the growth of the trees at the season of the year when rapid growth is dangerous; it protects the growth from frosts and when plowed under adds to the humus of the soil.

The plants used for cover crop purposes may be placed in three classes, namely, the nitrogen gatherers, the potash plants, and the ordinary ones used without special reference to the addition of plant food to the soil, as rye, oats, buckwheat, and perhaps weeds. The nitrogen gatherers are so named because they are associated with special forms of bacteria of the soil which extract free nitrogen from the air and store it up in the tubercles on the roots. The nitrogen so stored is in an organic form and after the death of the plants soon becomes available food for other plants. These are also called leguminous crops, and are the cow peas, soy beans, clovers, vetches, alfalfa, Canada peas and velvet bean. They store up varying amounts of nitrogen, potash and phosphoric acid, the amounts being influenced by climatic and soil conditions. This class of plants can be used to great advantage to improve soil more or less poor in humus and the nitrogen compounds. The orchardist should not make the mistake of letting a cover crop continue growth after the ground is in condition to plow. While it will of course add more vegetable matter to the soil to do so, there is danger of injury to the trees by drying out the soil too much. However, weather conditions will largely control this feature; if there is plenty of rain the crop may naturally be allowed to grow longer before plowing under.—(Del. Col. B. 61.)

The amounts of seed per acre mentioned below are abundant to give satisfaction, providing the soil is at least fairly good and the weather fairly favorable. If the fruit grower wishes to err on the right side he may sow more seed; with some crops this will add materially to the expense of the crop, but with others it will not. The amounts of seed per acre and crop or combination of crops which are desirable to use are as follows: Rye, 1 to 1½ bushels; cowhorn turnips seed, 1 to 2 pounds; dwarf Essex rape, 8 to 10 pounds; red, mammoth or crimson clover, 15 to 20 pounds; cowpea, 90 pounds; soy bean, 90 pounds; hairy vetch, 40 to 50 pounds; alfalfa, 30 pounds; hairy vetch, 40 pounds and rye 30 pounds; hairy vetch, 20 pounds and cowpeas or soy beans 45 pounds; hairy vetch, 20 pounds and turnips 12 ounces; hairy vetch, 20 pounds, crimson clover 8 pounds and turnips 8 ounces; hairy vetch, 20 pounds and red, mammoth or crimson clover 8 pounds; turnips, 12 ounces and crimson clover 8 pounds; turnips, 12 ounces and soy beans or cowpeas 40 pounds; dwarf Essex rape, 4 pounds and rye 1 bushel; rape, 4 pounds, soy beans or cowpeas 40 pounds and rye 20 pounds; alfalfa, 15 pounds and red, mammoth or crimson clover 7½ pounds. Many other combinations may be used successfully. The object should be to use such a mixture of crops that a part at least shall live over winter. A few of the combinations above contain all fall crops and for that reason are not so desirable as though they contained a part of those that live through the winter and grow in the spring.—(Del. Col. B. 61.)

The following table shows chemical analysis of cover crop plants and date of seeding in Delaware orchard:

	Cowhorn Turnips	Rape.	Crimson Clover.	Red Clover.	Alfalfa.	Hairy Vetch.	Cowpeas	Soy Beans.
Seed Sown	July 22	July 22	July 22	July 22	July 22	July 22	July 22	July 22
Sample taken	Nov. 15	Nov. 16	Nov 22	Nov. 22	Nov. 20	Nov. 19	Nov. 7	Nov. 11
Lbs. green tops	11297	26620	18800	6909	5430	13150	5933	10952
Lbs. air-dry roots	*20522	864	413	1212	1980	600	394	756
Total yield	31819	27484	19213	8121	7410	13750	6327	11708
Lbs. Nitrogen								
In Tops	64.4	116.2	128.2	69.8	54.8	108.0	65.2	130.9
In Roots	45.1	13.2	6.2	33.2	40.4	13.2	4.3	9.3
Total	109.5	161.3	134.4	103.0	95.2	121.2	69.5	140.2
Lbs. Potash								
In Tops	80.3	148.2	84.0	46.5	32.2	78.4	47.4	46.2
In Roots	62.3	13.1	4.2	9.9	9.5	7.1	2.4	1.8
Total	142.6	161.3	88.2	56.4	41.7	85.5	49.8	48.0
Lbs. Phos. Acid								
In Tops	14.3	41.8	59.2	18.9	13.1	22.5	16.6	37.8
In Roots	11.7	5.1	2.0	10.1	8.5	4.7	2.3	2.4
Total	26.0	46.9	61.2	29.0	21.6	27.2	18.9	40.2

*The turnip roots were weighed in their natural state just after being dug; this is, therefore, not air dry weight.

—(Del. Col. B. 61.)

The Intensive Trucker.—Truck farming is successful only as intensive methods are applied. It requires a large expenditure of capital and labor. Much depends upon soil and climate. Soil can be improved by judicious and liberal fertilization, and unfavorable climatic conditions may be partly overcome. One successful truck farmer is thus described:

The splendid success achieved on this farm (see below) is, as is nearly always the case, largely attributable to the personality of the man. It is the fruit of a dogged determination to win, and of industry intelligently applied. To use his own words, "I had to succeed." The farm is no better than others along the river, some of which are even more advantageously located than this one. But he saw the need of the industrial community at his door and set about to supply it. He has made the best use of his land. He has worked along the lines of least resistance. He produces the crop that gives the largest net returns for the labor. He grows what the other fellow doesn't. He studies the market. When a demand arises he has something to supply it. He possesses the rare combination of being a good producer and a good seller done up in the same package. He is a good manager of men. He is willing to live and let live. If we were to measure his success on a percentage basis we would make it:

Individuality	75 percent
Advantageous location of farm	15 percent
Land	10 percent

The justice of the small percent given to the land in this particular case is apparent from the following: When he took charge of the farm the gross returns from it were less than the amount he now pays for rent. The soil upon which he now produces his crops of 175 bushels of potatoes per acre, his melons and garden vegetables, produced only 8 bushels of rye per acre. This land he brought up to its present high state of fertility by the use of cowpeas and manure. Now he no longer needs the cowpeas. In four years by this method he increased the yield of rye from 8 to 22 bushels per acre. The practice of raising two, and in some cases, three crops on the same land each year is a distinguishing feature in the management of this farm. In this way the area devoted to the garden crops is more than doubled. It is practiced with the beets, onions, late beans, early sweet corn, melons and turnips.

Sweet corn is another important source of income on this farm. Successive plantings are grown, beginning with Premo for the very early and finishing with Country Gentleman for the latest. Plantings are so timed as to give a constant supply of green corn from July until frost.

Other Crops.—On that part of the farm devoted to potatoes, melons, cabbages, etc., no particular rotation system is used; although, except in the case of potatoes, the same crop is rarely raised on the same land more than two years in succession. Potatoes produce a larger amount of gross income than any other one crop on the farm. They are grown exclusively on the second bottom. Repeated failure has followed attempts to grow them on the first bottom. Early varieties are planted, as the late varieties have proven unprofitable. Potatoes have been raised for the last 15 years on the same field. Crimson clover and rye are sown after the potatoes have been harvested. The rye is manured during the winter, using from 10 to 12 tons per acre, and is turned under in the spring after it has made a good growth. The potatoes are put in the ground with a planter and about 500 pounds per acre of high grade steamed bone is used in the row. The tubers are harvested with a digger. Alternate rows are dug and the vines thrown on the intervening undug rows, and the rows thus vacated are planted to late cucumbers. The digger leaves the ground in good condition for the cucumbers. The only further attention needed is the running of a small one-horse roller over the rows. This roller is a handy contrivance made from a sewer tile. In digging the remaining rows the hitch to the digger is so arranged that very few cucumber vines are injured from trampling by the horses.

The following items of gross receipts and expense are taken from the day book of this farm for the year 1909:

GROSS RECEIPTS.

Alfalfa hay	$1,295	
Corn, 700 bushels at 70c per bushel	490	
Wheat, 100 bushels at $1 per bushel	100	
Total farm crops		$1,885
Potatoes, 3,000 bushels at 85c per bushel	$2,550	
Melons	297	
Cabbage	150	
Sugar corn	500	
Other small stuff	400	
Total garden		$3,897
Sheep (wool only)	$ 175	
Hogs	300	
Chickens (eggs)	150	
Total live stock and poultry		$ 625
Bank props*	$ 275	
Outside labor (husking and shredding)	150	
Total miscellaneous		$ 425
Total gross income		$6,832

EXPENSE.

Rent		$1,200	
Interest on investment—			
Live stock (owner's valuation)	$2,260		
Equipment (owner's valuation)	3,500		
Total	$5,760 at 5%	278	
Labor		1,084	
Manure		225	
Commercial fertilizers		270	
Five per cent depreciation on machinery		175	
Repairs on machinery (1909)		160	
Taxes		40	
Seeds		70	
Insurance		5	
Total expense			$3,457
Net returns from the farm			$3,375

No household account is kept, so that the surplus over the cost of living is not obtainable. The tenant considers his time worth $8 per day. This would amount to a salary of $2,500 per year, and would still leave him a comfortable balance of $875 for a sinking fund.—(Ohio Ex. Sta. B. 107.)

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*Stakes to support earth banks.

Intensive Methods on Large Farms.—On large farms or on farms where large areas are devoted to the cultivation of single crops, such as wheat, corn, tobacco, rice and cotton, the close intensive methods applicable to the small farm, owing to the high price of labor, cannot be so successfully applied; but even there the great aim should be to secure the highest yield possible from every acre. Drainage, crop rotation, fertilization, wise selection of seed, correct plowing, careful planting and proper cultivation, all parts of intensive farming methods, can be applied to the large or single crop farm.

Southern Conditions.—The tobacco growers of the present generation have as their heritage the fields once fertile but now impoverished by the unconsciously wasteful methods of their ancestors. This method of exploiting the superfluity of fertile land in a new country has generally prevailed in other sections, but its evil effects have been more aggravated in the South because of the essentially one-crop system of farming and the absence of a live stock husbandry.

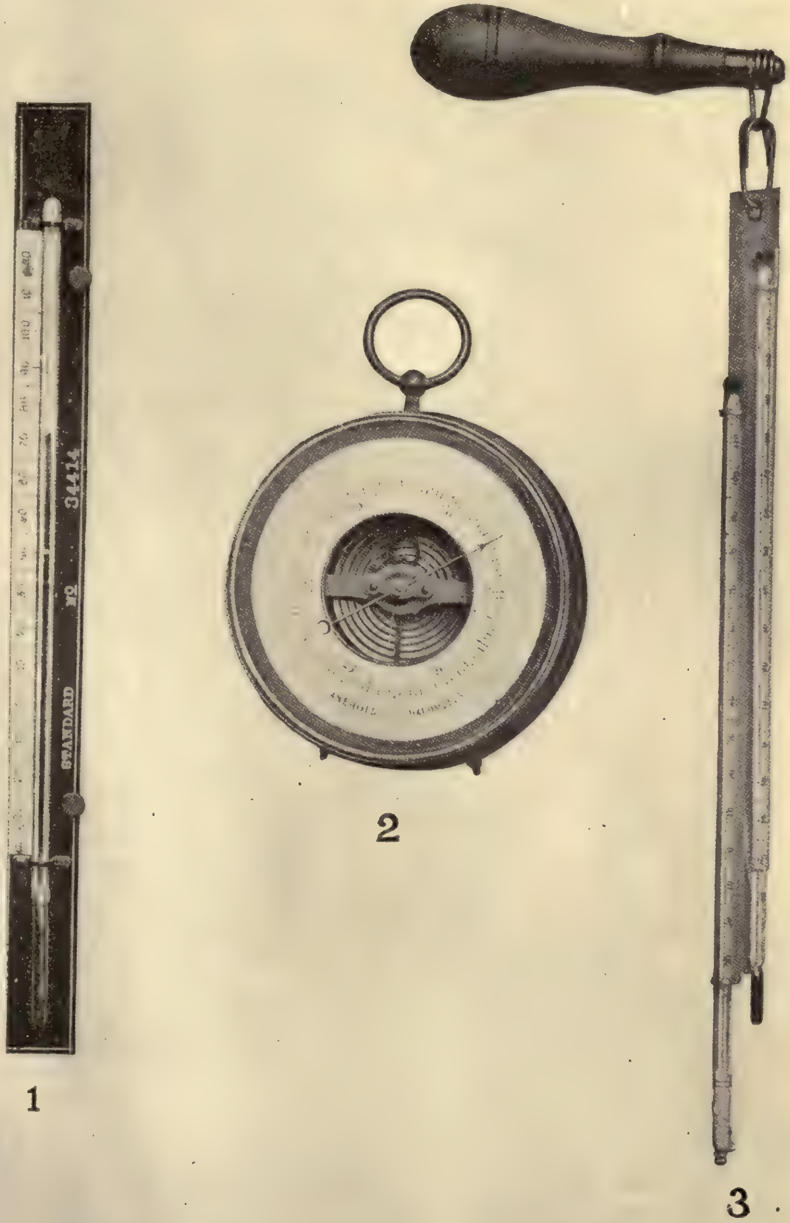
Conditions now, however, are radically changing economically in that section and elsewhere. Both land and timber are rapidly increasing in value, and in place of a plethora of cheap labor farm helpers are now becoming extremely scarce and obtainable only at a greatly advanced wage. This combination of new conditions renders the system of clearing and subsequently abandoning land comparatively unprofitable. Agricultural methods are now in process of adaptation to a new set of economic conditions. In the future a large proportion of the tobacco produced must be grown not upon fresh land but upon old land, and the fundamental present-day problem of the grower is how profitably to restore the depleted fertility of the old fields. The time consumed in cultivating an acre of infertile land is nearly as great as that required for an acre of highly productive land, and it will not pay to employ high-priced labor on soils of low productivity. In restoring the crop-producing power of these soils, undoubtedly the most important step is to increase the humus supply. The diversification of crops, a greatly improved rotation system, an effective live stock husbandry, and the general introduction of much more intensive methods will constitute the better and more profitable methods of the future.—(Y. B. 1908.)

Intensive Farming With Corn.—What is known as kernel-spaced checking in corn planting combines the advantages of the two methods now used in planting, and largely overcomes the disadvantages of those methods. In all fields of corn planted with the most modern check-rowers can be found many hills containing a stalk that has not produced well. In many cases the stunting is due to the quicker starting of the other plants which enables them to monopolize space, moisture, fertility and sunlight. Such stunting, because of the nature of the corn plant, materially reduces the grain yield. Plants that are crowded to such an extent that they become slender and scarcely more than half their normal height are either barren or produce only nubbins.

The disadvantage under which the two or more plants of a hill are compelled to grow by the kernels having been bunched together is so plain that it is remarkable farmers have not long ago devised a method of checking corn that gives each plant room to form a normal root system. For a distance of 6 inches in every direction from the base of a normal corn plant the soil is crowded entirely full of roots. When several kernels are bunched together the roots of all the stalks of the hill are so matted together that the pulling of one stalk pulls out the entire hill, and the pressure of wind upon all the stalks is more likely to blow over the entire hill than when the stalks stand several inches apart in the hill, thus forming a broader base of support.

Increased yield without extra cost is abundant reason to cause a change of methods. A few other advantages of kernel spacing may be mentioned. It is easier to thin kernel-spaced hills, and the thinning can be done without injury to the remaining stalks. When the plants stand separately in the hills, an entire hill is less liable to be pulled out by the harrow, the weeder, or the cultivator. The entire hill is not so likely to be injured by accident, disease, cutworms, or corn-root insects. The better distribution not only affords each stalk better sunlight, but also shades the soil better, thereby lessening evaporation from the heated soil during the summer months. Increasing population and increasing value of land are sure to stop the long-continued practice of planting corn thinner as the land becomes poorer, making up the supply by planting more acres. Our future increase in corn production must be accomplished mainly by filling the soil with water-absorbing and water-holding humus, accompanied by thicker planting. This practice has produced 239 bushels of shelled corn on an acre in South Carolina, and 226 bushels on an acre in North Carolina.

Soils are not impoverished by producing large crops. On the contrary, the larger the crops and the more frequently they are produced the better the opportunity to enrich the soil by plowing under a sufficient portion of the vegetable matter produced. The soil should be kept busy enriching itself through the decay of vegetation, as forest lands enrich themselves. To most soils one or more mineral elements must eventually be applied to replace those which are removed from the farm in the form of grain or animal products. In planting corn in hills practically all corn planters drop all the kernels of the hill in a bunch. A study of the best conditions for growth and production indicates that bunch planting results in unnecessary crowding both above and below the ground, weakening the stalks and reducing the yield. Kernel-spaced checking combines the advantages and overcomes the disadvantages of drilling and checking, the two methods by which nearly all corn is now planted.—(F. B. 400.)



Instruments Useful in Observing Atmospheric Conditions.

[Fig. 1.—Thermometer, which measures temperature. Fig. 2.—Aneroid barometer, which measures pressure. Fig. 3.—Sling psychrometer, which measures relative humidity.]

Compared with the grasses, grains, and most other general farm crops, tobacco may be classed as one of relatively high commercial value. As each unit of increase in production in a high-value crop is worth more, expenditures to increase production will be found relatively more profitable. This may be illustrated as follows:

Suppose that under certain conditions corn without fertilizer yields 25 bushels per acre. Even if intelligently expended, under most conditions it would probably take $25 worth of fertilizer to increase this yield to 50 bushels per acre. With corn at 50 cents per bushel, the fertilizer would cost more than the corn is worth. The higher money-value crop of tobacco, however, shows different results. Take a case in which tobacco without fertilizer would produce 600 pounds per acre. Intelligently expended, an application of fertilizer costing $25 an acre would usually increase the yield to upward of 1,200 pounds to the acre. At 8 cents a pound this 600 pounds increase in production would amply justify the expenditures for fertilizer. This example can be extended by farmers to many other crops.

Considering the matter in another light, it is apparent that an increase in the commercial value of any product will warrant an additional expenditure to obtain each increased unit of production. At 6 cents a pound for tobacco, 400 pounds increase in yield will just pay for the use of $24 worth of fertilizer; at 8 cents a pound, it will take but 300 pounds increase to pay the fertilizer bill; at 10 cents, 240 pounds. This illustration, however, is not to be taken as an argument for the use of $25 worth of fertilizer on tobacco or against the use of it on corn.

Generally speaking, then, tobacco, being a high-value crop, justifies a greater expenditure for fertilizer and greater care in soil preparation, cultivation, and handling than do other general farm crops of lower commercial value. It is also true that as tobacco increases or decreases in price so does the profit resulting from fertilization increase or decrease; that is, tobacco at 10 cents a pound is more likely to pay for increased expenditures in production than tobacco at a lower price, and the percentage of profit for the increase in expense is higher at 10 cents than it is at a lower price.

It is also true that tobacco is peculiarly subject to variations in price, owing to differences in quality resulting from the methods employed; and it frequently, in fact usually, happens that better fertilizing, preparation of the soil, cultivation, and handling not only increase the yield, but result in a materially better average price for the crop, conditions of soil, climate, etc., remaining the same.—(Y. B. 1908.)

One cotton farm in the South, previously badly managed and run down, was changed by progressive farm operations, combining thorough tillage, crop rotation, barnyard manure and commercial fertilizers, into a very productive and profitable enterprise.

The present owner was a farmer of experience when he purchased the farm, and he knew the value of the rotation of crops, thorough tillage, and the importance of decaying organic matter, or humus, in the soil. He adopted a rotation, bought stable manure, and began feeding cattle for the purpose of converting part of the roughage and grain of the farm into animal products and making farm manure for use on the land. By this method and by the judicious use of commercial fertilizer he succeeded in producing the first year a yield of 1 3/5 bales of cotton, 37 bushels of corn, and 10 bushels of oats to the acre. These yields have been gradually increased, until during the last two years 2¼ bales of cotton, 85 bushels of corn, and 80 bushels of oats per acre have been obtained. The rotation adopted was as follows: First year, corn, with cowpeas planted between the rows at the last working of the corn; second year, winter oats, followed by cowpeas for hay, and third year cotton. Under the present management the soil has been plowed broadcast for both cotton and corn with a 2-horse turning plow cutting 10 inches deep, followed by a 1-horse subsoiler breaking the furrow bottom to an additional depth of 7 inches. This has given the land two deep and thorough plowings each round of the three-year rotation.

Under previous management the land on this farm washed and gullied somewhat. This has been largely overcome by deep and thorough tillage. However, to check the possibility of washing during exceptionally heavy rains the soil is now plowed in long beds 60 feet wide. This leaves it in a series of broad, low "lands" with shallow depressions between. During heavy rains such water as the soil can not immediately take up finds its way gradually to the shallow depressions, which, having no outlets, hold it until it slowly sinks into the subsoil. As this soil is open and porous in texture and absorbs water readily, there is no danger of puddling from water standing in the furrows between the lands, and this method of plowing eliminates the necessity of terracing.—(F. B. 364.)

The land was flat-broken or plowed broadcast, ten inches deep, in sixty foot beds, with a two horse turning plow. A subsoil plow followed the turning plow breaking the furrow bottom to a depth of seven inches. Black manure was liberally used. Just before planting time the manure was thoroughly mixed with the soil and the commercial fertilizer applied with a distributer. The plants were thinned out to an average of one plant every four feet in the row, and the whole received repeated cultivation. The important features in the management of the farm were:

(1) The deep plowing in broad, gently sloping lands, instead of terracing, to control surface water and prevent the formation of gullies.

(2) The deep and thorough system of soil preparation for crops, by broadcast plowing and subsoiling.

(3) The adoption and practice of a systematic rotation of crops, including money crops (cotton is the principal money crop), feeding crops (corn, oats, cowpeas), cleansing crops (the clean-cultivated corn and cotton), and a manurial crop (cowpeas), thus providing for the maintenance of soil fertility and for a liberal

cash revenue besides the necessary hay and grain for maintaining the work stock and a small herd of cattle and hogs.

(4) The feeding of cattle and hogs for the purpose of converting a part of the grain and roughage of the farm into animal products for sale and into manure for the maintenance of soil fertility.

(5) The maintenance of and the increase in the supply of humus in the soil by the use of barnyard manure and the plowing in of vegetable material for the control of moisture, plant food, ventilation, and germ life, most important factors of soil fertility.

(6) The application of barnyard manure to the cotton land in a rotted and moist condition, covering it immediately two or three months before planting, and the thorough mixing of the manure with the soil before putting in the crop, thereby diminishing, if not entirely eliminating, the tendency of the crop to burn, which often occurs in dry seasons when the crop is planted on recently applied coarse manure.

(7) The greater space given each individual cotton plant as the soil became more fertile and the plants grew larger, thus giving room for large, well-branched, heavily fruited plants.

(8) The closer planting of the more slender growing corn as the soil became more fertile, thus insuring a greater number of stalks to the acre and increasing the possibility of securing larger yields.—(F. B. 364).

While the system of managing this farm could be carried out in detail on comparatively few other farms, one or more of the main features of the system are applicable to nearly every farm in the cotton belt.

Crop rotation can be introduced with advantage on every farm not already practicing it. On nearly every farm it would be economical to grow the grain and forage necessary for home consumption, and it would be profitable to grow some for market also. Some form of stock raising, dairying, mule raising, or cattle feeding could be made at least self-sustaining and indirectly profitable through its influence on soil fertility.—(F. B. 364.)

Necessary Intensive Requirements.—Intensive farming presupposes that all the coordinating factors incident to the production of a paying crop shall receive their proper share of attention. In order that deep plowing, thorough preparation, and careful cultivation may pay, the field must be made fertile, a good stand must be secured, and the crop must be planted at the most favorable season; conversely, in order that liberal fertilizing may pay, the field must be so prepared and cultivated that the growing crop can best utilize large amounts of available plant food; and, above all, strenuous efforts should be made to secure a good and uniform stand. The crop should also be planted as close as it can be without injuring its quality. Such experimental data as are available indicate that the yield of tobacco is increased by closer planting up to a certain point, and that the texture of the leaves is finer. Closer planting may thus be taken advantage of to prevent the in-

Records of State Prize Winners in Growing Corn in 1910.

Names and Addresses.	Character of Soil.	Yield.	Cost per bushel.	Depth of plowing.	Kind of seed corn.	Distance between rows.	Distance between hills.	Number of cultivations.	Remarks.
		Bushels.	*Cents.*	*Inches.*		*Feet.*	*Inches.*		
Hughey Harden, Banks, Ala.......	Sandy, clay subsoil...	120	32	14	Prolific	3 1/6	8	6	Walked 3 miles to school.
Ira Smith, Silver, Ark..............	Sandy loam	119	8	14–16	Single ear.....	3 1/2	13	5	Won prizes for Japan clover and popcorn.
Joseph Stone, Center, Ga..........	Yellow clay...........	102 5/8	29	12–15	Prolific	4 1/2	14	5	Only 11 years of age.
Stephen Henry, Melrose, La.......	Sandy	139 4/5	13.6	12	Prolific	4	18	8	Third year in club.
William Williams, Decatur, Miss..	Second bottom.......	146 4/7	18	12	Prolific	4	15	6	Corn stayed green during drought.
Ernest Starnes, Hickory, N. C.....	Dark, sandy loam	146 2/7	27	8–10	Single ear.....	4 3/8	12	8	Corn followed clover.
Floyd Gayer, Tishomingo, Okla...	Black, sandy loam....	95 1/12	8	12	Single ear.....	3	14	7	Watered corn.
Jerry Moore, Winona, S. C........	Gray, sandy upland...	228 3/4	43	10–12	Prolific	3 1/2	6	11	24,000 stalks.
Maurice Olgers, Sutherland, Va...	Gray upland..........	168	40	12–15	2 ears to stalk.	3 1/2	10	5	Corn followed tobacco.
Norman Smith, Covington, Tenn..	Sandy, clay subsoil...	125 1/2	37	10	Single ear.....	3	10	5	Used compost.
Rodger Smith, Karnes City, Tex..	Black river bottom...	83 1/9	13 3/8	8	Single ear.....	3 1/6	14	5	Bud worm did damage.
Archie Odom, Bennettsville, S. C.	Dark, sandy loam....	177	23	15	Prolific	3 3/4	7	6	Did not use hoe.
John Williams, Tuscaloosa, Ala...	Dark sand, clay beneath..............	83 3/4	49	19	Prolific	4	10	6	Land made 12 bushels 4 years ago.

—(B. P. I. B. 647.)

dividual leaves from becoming over-large and coarse, while increasing the total yield per acre at the same time. Higher topping to a certain extent may also be practiced to accomplish the same purpose, although the higher the plant is topped the less uniformity will there be in the leaves from different portion of the plant. —(Y. B. 1908.)

Intensive Methods Practically Applied.—The good results following intensive farming is well illustrated by the work done by the Boys' Clubs organized in all parts of the country. The principal object of the clubs is to teach intensive farming, and the plowing, planting and cultivating by members of the clubs are of the intensive character. The accompanying table of what has been accomplished in this line is an object lesson worthy consideration. It should be noted that each of these boys prepared his land in the fall or winter. They not only plowed deep but harrowed well before planting. Some planted corn following clover, cowpeas, or rye, and some planted cowpeas in their corn. All secured good seed. The record is for one acre.

ROTATION OF CROPS.*

Crop rotation has become one of the most important problems in the agricultural development of the country; closely connected as it is with other features of farm management. It is one of the most difficult and complex problems that confronts the agriculturist, and it cannot be said that any infallible system has been fully developed. The principal difficulties arise from the fact that the establishment of a successful rotation system is a long-time proposition, involving plans reaching many years into the future, and the difficulties vary in each locality, owing to soil and climate conditions and access to market.

Every farmer has realized the dangers which follow growing the same crop too frequently on the same land as well from the inroads of disease and insects. In every section of the country it has been forced upon the farmer that if he desires success he must do something to restore and maintain the fertility of his soil, and crop rotation is one of the best means for accomplishing this result. It is now acknowledged everywhere to be an essential feature of good husbandry.

What It Is.—Systematic crop rotation is letting one crop follow another on the same tract of land in order to rest the soil in one sense, and in another sense to restore to the soil some of the plant food taken away by the preceding crop or crops.—(Y. B. 1905; B. P. I. B. 187.)

Chemical, physical and biological studies of the soil, and experiments determining how crops yield under varying conditions, as in continuously growing a given crop, or in growing crops in rotation, are gradually unraveling the mysteries of soil fertility. The soil is so complex in its relation to crops that it has been and still is one of nature's greatest puzzles. Its solid mineral particles, making up the body of most soils, its small per cent of decaying organic substance mainly of plant origin, its water distributed in exceedingly thin films over the surfaces of the particles, its abounding species of bacteria operating in the water on the decaying plant substances and affecting the solution of the minerals, minute quantities of mineral and organic compounds in the soil water, fungus plants, and the ever acting and hungry roots of crops constantly taking in from the soil mineral and nitrogenous food and giving out solvents, make of this an almost bewildering maze of physical, chemical and biological changes. It is not strange that scientists are slow in arriving at an understanding of or that no one is now prepared to comprehensively state the laws of fertility. The study of the biological activities in the soil is throwing new light upon the chemistry of fertility; and the study of soil chemistry will continue to show many facts concerning the preparation and use of plant food in the soil.

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* **For illustrations, see pages 193 and 668.**

It is well known that vegetable matter or humus improves most arable soils. It at least improves soils that are somewhat run down by grain growing. Wherever partially decayed manure or roots are found in the soil, moisture is usually present, and such material also permits a free circulation of air. The real value of this condition of the soil is explained by the following facts. In order to grow, plants must have food in a soluble form in contact with their roots. Plant food is made soluble by the decomposition of organic matter and disintegration of mineral matter. Disintegration of mineral matter is aided very materially by the acids formed by decomposition of vegetable matter. Decomposition of organic matter in the soil takes place as the results of the action of bacteria and the bacteria which render plant food available can act only in the presence of air and moisture.

By a rational rotation of crops the land is kept in far better tilth than would otherwise be the case. The importance of the presence of organic matter in process of decomposition is often far greater than is generally supposed. Thus the occasional turning under of a grass or clover sod, or the plowing in of a green crop, is generally followed by marked physical benefit. By this procedure fresh food is introduced into the soil for the bacteria and fungi, many of which are highly beneficial aside from their direct aid in effecting the decomposition of the vegetable matter.—(Univ. of Minn. B. 109; S. Dak. Agr. Col. B. 79; R. I. Ex. Sta. B. 74; Y. B. 1905.)

Necessity of Rotation.—That the fertility and productivity of farm soils are rapidly deteriorating is a fact so well established that it needs no confirmation. Even the rich soils of the Illinois prairies have shown decided marks of decay, and this is true of the soils of every State in the Union and every Province in Canada. The question is being asked by nearly all farmers, "How can the worn lands be most speedily and economically restored to their primitive fertility?" This question is especially serious in the corn belt section. With the kind of farming carried out on the better class of farms, the crops that are grown and the live stock kept, rotation is well nigh indispensable. The yields by the ordinary methods of farming cannot be kept up much less increased without it. Rotation adds system to the management of the farm. It is known definitely what is to be done each year, making possible an estimation of the general returns that may be usually expected from the farm.

All plants do not draw to an equal extent upon the various manurial ingredients of the soil. Furthermore, plants are unlike so far as concerns their power to assimilate individual ingredients. This is probably due to their sending their roots to different depths and also to an unlike solvent action of the root juices upon the constituents of the soil. By rotating crops, injury by insects is lessened. Losses caused by fungous and bacterial diseases may also be materially reduced. The soil is maintained in good tilth, which is an item of great importance. Certain minute organisms which are helpful to plants are more likely to increase in soil where crops are rotated than where no regular system exists. Weeds are more readily eliminated or avoided where crops are regularly rotated than under an irregular, slip-shod system of farming.

The conservation of the organic matter in the soil is one of the important considerations of crop rotation, and the waste that annually goes on through soil cultivation makes necessary some method of restoring the natural conditions, and rotation is one of the methods employed.—(N. La. Ex. Sta. B. 71; Ohio Ex. Sta. B. 111; S. Dak. Ag. Col. B. 79; R. I. Ex. Sta. B. 75; Bu. Plt. Ind. B. 187.)

System of Rotation.—No general system can be recommended. Experiments have not yet been able to establish a system that will work equally well in all localities. In fact the experiments have not demonstrated that a system giving good results on one farm will give the same results on another farm in the same locality. Climate, soil and methods of farming are important factors to be considered in adopting a system of rotation. Even all tests under practically the same conditions have not been successful.

In no field of scientific investigation or of the practical application of scientific principles is dogmatism more utterly out of place than in the study or practice of crop rotation. The factors of the problem are so local and individual in their nature, so closely associated with the local characteristics of each farm and its environment and the individual tastes, abilities, and limitations of each farmer, that no definite and specific directions can be given for establishing a rotation for any farm until all the factors of each farm are as carefully studied.

Diversified Crops.—Another important consideration with every farmer who is planning to diversify his crops in order to secure a system of crop rotation is to adopt one that will enable him to receive the largest cash returns for his crop. All crops may be roughly classified under three heads: Exhaustive, intermediate, and restorative. These terms must not be taken too literally. All crops which are harvested and removed from the land take from it more or less plant food and might therefore be said to be "exhaustive." No crop "restores" to the soil any considerable amount of plant food unless it is plowed under for green manure or is allowed to decay upon the surface. But, nevertheless, certain crops leave the land in poorer condition for a subsequent crop of some particular kind than it was before they were raised. These are designated as "exhaustive" crops, and include wheat, oats, barley, rye, and millet. Their ill effects upon subsequent crops may be due to a reduction of the available plant food; to an increased growth of weeds, fungi, or injurious insects; to a change in the physical condition of the soil, particularly its water content; or to a reduction in the quantity or activity of beneficial lower organisms. "Restorative" crops have the opposite effect. They leave the soil in better condition for certain crops than it was before. Among restorative crops may be mentioned corn, potatoes, beans, peas, clover, alfalfa, and perennial grasses grown for meadow or pasture. "Intermediate" crops are those that have, in some respects, a beneficial effect upon certain crops which follow them, while in other respects their influence is detrimental. The sorghums, cane, milo, and kafir belong to this class. Their beneficial effects are due to the fact that, like all cultivated crops, they reduce the amount of weeds in subsequent crops.

In addition to and in a certain measure independent of the above-mentioned classification is the problem of crop sequence, or the relations which two crops bear to each other independent of any apparent difference in the conditions of the soil brought about by their growth. For instance, two crops may be equally exhaustive, but when grown consecutively, better results will be obtained if they are grown in one sequence than when the opposite sequence is followed. Oats following wheat generally give better results than wheat following oats. Or, again, a restorative crop may have a more beneficial effect upon some certain exhaustive crop which follows it than it has upon some other equally exhaustive crop. Wheat generally responds more readily to the effects of a corn crop than does oats.—(Ont. Dept. Ag. B. 156; Bu. Plt. Ind. B. 187; Univ. of Minn. B. 109.)

Fertilizers.—No system of crop rotation can be devised that will prove successful without a fertilizing system. A soil that is called upon year after year to produce a crop will in the end be exhausted of the three principal elements of plant food,—nitrogen, phosphoric acid and potash. These elements of plant food must be returned to the soil in some way. Rotation will not alone accomplish this. A system of fertilization must go hand-in-hand with rotation if success is desired. This can be done to some extent by using in the rotation some crop that being plowed under will act as a fertilizer.

Experiments.—The various Experiment Stations have accomplished wonders in the way of tests of rotation. These Stations discover and formulate general principles. The application of those principles must be by the farmer himself. The farmer who profits most by the work of the Experiment Station is he who is himself an experimenter. Experience brings him certain knowledge. Many experiments which farmers attempt, however, are either valueless or actually misleading, because of failure to observe some of the essential conditions of successful experimentation, for investigation in agriculture by experiment is a business by itself, entirely distinct from ordinary farming, and many a good farmer will overlook points of vital importance to the success of an experiment until his attention is called to them.

A matter of first importance in preparation for field experiments is that the soil shall be as nearly uniform as possible in character; to know whether the soil is of sedentary drift or alluvial origin.

A sendentary soil is liable to be more uniform than a drift or alluvium, because in the case of transported soils there is generally a more or less uneven deposit of materials, an excess of gravel and coarse sand appearing in one spot and of silt and finer particles in another. A heavy sheet of drift may sometimes become weathered into practically the same condition as a sedentary soil, while it would seem that some of the great loess deposits would offer especially good conditions to the field experimenter, the loess being the fine grained, silty soils found in some of the Western States, and whose origin is apparently due to the blowing of the dry surface dust into banks and hillocks, sometimes many feet in depth.

Experiment Plots.—Farmers generally have the idea that experiment plots should be made as large as possible, an idea naturally following their observation of the inequalities of most soils; but the practical difficulty in the way of using large plots is the fact that for a comparative experiment the soil must be as nearly absolutely uniform as possible, and it is extremely difficult to find large areas having sufficient uniformity. In almost all cases it will be found better to use a large number of small plots than a small number of large plots, since by multiplying the plots the variations of the soil can be more evenly distributed. A field of ten acres, for example, in which it is desired to make ten comparisons, will yield results of far greater value if cut into 100 plots containing one-tenth acre each, giving ten plots, distributed over the field, to each particular comparison, than if only ten plots are employed.

It is highly important that the plowing and fitting of the land for a comparative experiment be as uniform as possible in every respect. A difference of a few weeks in date of plowing may cause as great a difference in yield of crop as will be produced by difference in fertilizing, and far greater than is usually observed between varieties. For this reason the plowing should, as a rule, be done across the plots, and when it becomes necessary to plow the plots separately, in order to ridge them, the work should be pushed forward as expeditiously as possible.

Seed.—The selection of seed is a very important matter in field experimentation. Defective seed means an imperfect stand, and an imperfect stand means an undesirable and inconclusive experiment. Not only should the seed be strong in vitality, but it should be uniform in size.—(Ohio Ex. Sta. C. 96.)

Efforts of the Experiment Stations.—All the Agricultural Experiment Stations have conducted many tests, but all have not reached the same results; even under similar conditions; perhaps this is partly due to different system of rotation, and partly due to difference in soil, climate, and the amount and character of the fertilizer used. These experiments have been mainly of three, four and six year rotations, with substantially the following results:

1. There is choice even among good rotation schemes. In these experiments all those cropping systems gave large net profits in which corn, small grains, and timothy and clover sod laid for one to four years, were arranged in a four to seven year rotation, with light manuring once during the course.

2. The standard five year rotation followed on the check plot is: First year, corn, following the application of eight tons of manure per acre; 2nd year, wheat; 3rd and 4th years, meadow; 5th year, oats. This rotation has given an average gross income per year, based on average farm prices, of $14.08. The cost of production, including $3.50 land rental, is $9.05, leaving a net annual income of $5.03 per acre.

3. Several other rotation schemes were even more profitable than the one used for a standard; while crops grown continuously and crops not properly arranged in the rotation were less profitable or even resulted in a loss.

4. The best rotations in these experiments have yielded a product worth from four to six dollars per acre more than is obtained on the average farm throughout the state.

5. Many farmers would profit were they to practice systems of cropping which include the alternation of grain crops, grass crops as clover and timothy sown together, and cultivated crops arranged in any rotation scheme best suited to their conditions.

6. The experimental evidence shows that the use of manure and clover add to the nitrogen and that manure, also clover and timothy, add fresh vegetable matter to the soil.

7. Any systems of cropping that have provided for the maintenance of a supply of vegetable matter in the soil, either by manuring or by growing pasture or meadow crops, have given profitable returns.

8. The plots which have grown cultivated crops, such as corn, potatoes and mangels, continuously without manure, have given poorer returns than have the plots which have grown grain continuously without manure. This is believed to be due to the fact that the intertillage given these crops has caused a more rapid depletion of vegetable matter than has taken place in the continuous grain fields.

9. The four-year rotation: First year, millet; 2nd year, barley; 3rd year, corn; 4th year, oats, gave no better returns than did the plot on which wheat was grown continuously. All of the

crops in this rotation are considered exhaustive crops, as they all decrease rather than increase the supply of vegetable matter in the soil.

10. The practice of sowing grass seed with the grain on corn land that is disced in the spring in place of fall plowing, has resulted in securing a grass stand in nearly every instance. It has proved to be the surest method of obtaining a grass stand of any tried at University Farm.—(Minn. Agr. Exp. Sta. Bul. 109; Report of 10 Years on 44 Rotation Plots.)

The analyses of the soils of the forty-four experiment plots at the beginning and the close of the ten year period showed:

(1) The maximum amount of nitrogen was lost when the soils were cropped exclusively to wheat, corn, potatoes and mangels. When these crops were grown continuously there was an average loss of .034 per cent of nitrogen, equivalent to 1,100 pounds per acre. In the case of wheat two-thirds of this nitrogen was not utilized as plant food, but was lost by the rapid decay of the humus with the formation of soluble and volatile nitrogen compounds. When the crops were grown continuously the soils lost .5 of a per cent of carbon, representing over one per cent of humus, or 20,000 pounds, equivalent to an annual loss of one ton per acre.

(2) There was an average gain of .014 per cent of nitrogen, equivalent to about 300 pounds per acre, in the case of twelve standard rotations, consisting of wheat one year, clover and timothy two years, oats one year, and corn one year, manured with stable manure at the rate of eight tons per acre. From one of the twelve plots there was a small loss of nitrogen. The results, taken as a whole, show the nitrogen content is maintained when clover is grown two years in a five course rotation, and then the application of nitrogen containing fertilizers is unnecessary. In practically all the rotations where clover was grown, gains of nitrogen were secured. There were no great differences in gains of nitrogen that could be attributed to the combination of any special crops with clover. Any substitution of crops in the rotation could be made without materially affecting the nitrogen content of the soil, provided clover was retained. When the crops were rotated, the carbon and humus content of the soil was maintained and in some cases slightly increased. The results show that wheat, corn, oats, barley, flax, rape, potatoes, mangels, millet, bromus and timothy can be grown with clover in three, four, five or six year rotations without loss from the soil of either nitrogen or humus. By rotation with clover, the nitrogen content was conserved, and in some cases slightly increased. The gains and losses of nitrogen are practically under the control of the cultivator.

(3) In the rotations where timothy and non-legumes were substituted for clover, a loss of nitrogen occurred, but the carbon (and humus) content was maintained. The conservation of the humus prevented rapid nitrification, and the loss of nitrogen from the soil only slightly exceeded that removed by the crops.

(4) The potash compounds of the soil were less soluble at the close than at the beginning of the ten year experimental period.

The formation of soluble potash compounds from the decay of the potash minerals did not keep pace with the amount removed as plant food and that lost in soluble forms in the drain waters.

(5) Systems of rotation, in which clover (and other legumes) form an essential part and in which farm manures are used, should be practiced to prevent depletion of the nitrogen and humus of soils, because the humus takes such an important part, chemically, physically and bacteriologically, in maintaining the fertility.

Crop Rotation Simple and Practical.—Crop rotation may be defined as a systematic succession of the three general classes of farm crops, namely, grain crops, grass crops, and cultivated crops, in such a way as to provide large yields of grain, pasturage and forage needed on the farm at the least expense of labor and fertility.

Rotation systems must be adapted to each farm or class of farms and to the particular condition of each farm. With a knowledge of what it is desired to accomplish by rotation, namely an improvement in the condition of the soil and a corresponding increase in the net income per acre, it is easily possible, knowing the character of the farm, the climate, the line of farming desired and the tastes of the farmer, to plan a systematic rotation for that farm which will give the desired results. The essentials of a good rotation are that the net yields in money per acre be maintained or increased, that vegetable matter be kept in the soil, and that the land be kept in good physical condition and reasonably free from weeds. Grass crops must be grown or barnyard manure applied, or both, to keep up the supply of vegetable matter. A cultivated crop occasionally and good tillage are necessary to kill out weeds and help put the soil in good tilth. These things are naturally brought about by alternating the three classes of crops—that is, one or more grass crops should appear on each field every four to eight years. Corn or other cultivated crops and manure should appear one or more years in the same period, and the remainder of the time grain may be grown.

This treatment cannot fail to keep the soil in much better condition than can be done by growing any one crop continuously, and it may be brought about by a very little planning, and without very seriously changing the acreage devoted to each crop. Most farms in the middle west have from one-eighth to one-half their tillage area in corn, and from one-eighth to one-half in grass each year. All the change that is necessary is to arrange these crops according to some regular system of rotation instead of growing each on the same field year after year.

1. The best average yields of wheat have been obtained in those rotations where that crop follows either corn or potatoes. Following these crops in the order of their merit as a preparation for the growth of wheat comes summer fallow, millet, vetch, peas, wheat and oats.

2. The drier the season or the more unfavorable the conditions for the production of a maximum crop of straw and grain, the more important becomes the introduction of a cultivated crop into the rotation.

3. Wheat being a more particular crop than oats, it should have a better place in the rotation than should the latter crop.

4. Flax is not more exhaustive of the fertility of the soil than are the other grain crops.

5. The growth of a nitrogen-gathering crop, as represented by Canada field peas and by vetch, has increased the growth of straw in the following crops without materially increasing the yield of grain. This has been the most marked where the peas have been plowed under as green manure, or "hogged off" on the land.

6. Plowing under peas for green manure has not as yet shown any benefits over a summer fallow.

7. At the end of eight years land that has grown wheat and corn alternately is producing better crops of wheat, of both straw and grain, than is similar land upon which wheat has been alternated with vetch and with summer fallow.

8. It has not on our soil proven profitable as yet to manure land that grows wheat alone.

9. It has proven decidedly profitable to manure land for corn. Not only has the yield of the corn crop been increased, but the effects of the manure have been shown in the increased yield of the following crops for at least four years.

10. The best rotations will include some perennial grass in which the land is laid down in sod for a short term of years. Present results indicate that brome grass is well adapted to use in short rotations.—(S. Dak. Ag. Col. B. 98.)

Methods of Rotation.—What is the best method of crop rotation? No man can tell that in advance. Farms differ in size and in soil, and farmers differ in knowledge and skill, and seasons change. It is safe to say that a good plan to follow is to let a long-growing crop be succeeded by one that is quick growing. Corn is a long-growing crop, gathered late, leaving the ground in excellent condition for a quick growing crop, such as oats or barley. In turn oats or barley are off the ground in good time for fall wheat planting. A good four-year rotation for grain farming is wheat, corn, oats, and clover, with an extra catch crop of clover seeded on the wheat land and plowed under the next spring for corn. Only the seed crop of clover should be harvested the fourth year; and all produce should be returned to the land except the grain and clover seed. (Where hay is made for the work animals, manure should be returned.) This system, with the addition of phosphate (and of limestone where needed), will maintain the fertility of the soil.

In live stock farming, two crops of corn followed by oats with clover seeding, and a full clover crop the fourth year, is a good rotation, and, if all the produce is used for feed and bedding and the manure returned with but little loss, the supply of organic matter and nitrogen will be maintained nearly as well as in grain farming; and quite as well if timothy is seeded with the clover and one or two additional years allowed for pasture. Only half as much phosphate will be required as in the grain system, but limestone should also be used where needed to make and keep the soil sweet.

It is almost universally conceded that clover should be included in every system of rotation. Experiments tend to show that one ton of clover is equal to four tons of barn-yard manure. The choice of rotating crops must, however, depend largely upon the soil, climatic conditions, and the knowledge possessed by the farmer. It is, and should be, the aim of the farmer to crop his land so as to get the largest cash return, and he should adapt any system to that end.—(Ohio Ex. Sta. B. 96; Univ. of Minn. B. 190; Univ. of Tenn. B. 90; S. Dak. Ag. Col. B. 98; Bu. Plt. Ind. B. 187; Miss. Ex. Sta. B. 101; R. I. Ex. Sta. B. 74, 75, 76, 135; Univ. of Ill. B. 141.)

Notes.—In some instances, as in the case of grain farms, it has been necessary to increase the proportion of the farm sown to grass. The continuous cropping of grain practiced so many years has reduced the amount of vegetable matter in the soil and increased the amount of weeds until the crop yields are so low as to make grain growing unprofitable. On such farms it is undoubtedly profitable to increase quite largely the proportion of the farm sown to grass, even though there is but little use for the hay, owing to the desirable effect the grass will have in building up and cleaning the soil. There are few cases in which roughage thus grown cannot be put to some profitable use, either by increasing the amount of live stock kept on the farm or at least buying stock cattle or sheep to feed during the fall and winter.

It should be understood that the growing of clover produces several effects on the land and upon subsequent yields of other crops, only one of which is due to the nitrogen secured from the air. In fact the chief effect of clover in increasing the yield of a subsequent crop of corn is not due to the nitrogen secured from the air, but rather to the liberation of phosphorus by the decay of the clover residues in the soil. The physical improvement of the soil and subsoil are also important factors in some cases.—(Univ. of Minn. B. 190; Univ. of Ill. B. 125.)

Another factor, and one that is gaining some prominence at the present time, is a proper sanitary environment for the roots. Investigations of the Bureau of Agriculture at Washington arouse the suspicion that the apparent exhaustion of soils is not due so much to the depletion of the stock of plant food as to the lack of proper sanitary conditions. Animals forced to exist in an atmosphere rendered foul by their own poisonous exhalations soon cease to thrive; the plant above ground likewise gives up waste products, which if not removed, become a menace to its safety; is it not therefore natural to expect that from the roots of the plant also there are excreta that, if allowed to accumulate, threaten its very existence? As proper ventilation is necessary to insure the health of the animal, as diffusion, drafts and winds must bring fresh air to the leaves, so must tillage or other treatment purge the soil of the injurious substances cast off by the roots. In this purifying process it is believed that air, and therefore cultivation and drainage, play an important part; certain fertilizer ingredients are effective under certain conditions, but more potent still is organic matter in the form of humus.

There is another method, however, of eliminating the toxic or poisonous effects of these excreta. Whatever they may be, it appears that those cast off by one variety of plant are not, as a rule, injurious to another variety, hence the possibility of rotation of crops. By the time the first crop comes round again, the intervening cultivations having stirred up the soil, exposed it to the weathering processes, allowed the air to enter in and permitted the humus to do its work, all the excretions injurious to that crop have been removed or neutralized, and a yield equal to the last one is secured. Hence it is that by proper rotation a farmer may go on cropping his fields from year to year, cropping them indefinitely, without any apparent exhaustion, and indeed by wise rotation even increasing the yield. —(Ont. Dept. Agr. B. 156.)

Among the most important considerations that should enter into any discussion of crop rotation must be the following: 1. Climatic conditions; precipitation, annual and seasonal; temperature, annual and seasonal; length of growing season, winds, frosts, etc. 2. Soil conditions; chemical, and physical or mechanical; effects of tillage upon soil water; effects of the growth of various crops upon the crop-producing powers of the soil, either by depleting the soil of its fertility, or changing its mechanical condition. 3. The relation that various crops bear to each other when grown in succession. 4. Effects of the application of manure in various ways and at different times. 5. Effects of summer fallowing. 6. Effects of plowing under green crops for manure.—(S. Dak. Ag. Col. B. 79.)

Summer Tillage.—This will almost invariably increase the yield of wheat, oats, or barley and will materially reduce the danger of complete crop failure due to drought. It may therefore be resorted to as a safeguard or temporary expedient to meet a possible emergency, but it can not be depended upon to produce as profitable spring-sown crops as may be produced by other methods. Very good crops can usually be raised by one plowing and one or two harrowings, as is shown by yields obtained from continuous cropping by ordinary methods. Each farmer must decide for himself whether he can afford to perform this additional amount of labor in order to secure an increase in yield, which if the season proves favorable may be small, and to materially reduce the danger of total failure if the season proves unfavorable. He should, however, remember that summer tillage will in no way reduce the many dangers other than drought, such as unseasonable frosts and high winds, to which crops are subject. In fact, these dangers may be materially increased under a system of summer tillage.—(Bu. Plt. Ind. B. 187.) In planning a system of rotation it is well to observe the following rules:

(1) Select as large a number of restorative and as small a number of exhaustive crops as is consistent with the general plan of farm organization.

(2) Arrange the crops in the rotation so as to have the exhaustive and restorative crops alternate as far as possible.

(3) Observe the proper sequence, both between restorative and exhaustive crops and between two exhaustive crops where it becomes necessary to grow two such crops consecutively.

(4) Select the best varieties or strains and use the quantity of seed and the method and time of seeding best adapted to the locality.

(5) Plow and prepare the seed bed at the time and in the manner best adapted to the crop, the soil, the climate, and the most economical distribution of labor through the year.

(6) Obtain all available information concerning yields, cost, and prices of crops grown in the locality, and plan to grow those crops that will yield the largest net return per acre with the least depletion of soil fertility.

(7) Feed as large a proportion as possible of the crops grown and return the manure to the field.

(8) Raise the kind of live stock yielding the largest net profit and best adapted to the particular farm and locality and to the preferences of the farmer who handles it. Very few farmers ever make a success of raising any kind of live stock the care of which they do not enjoy.

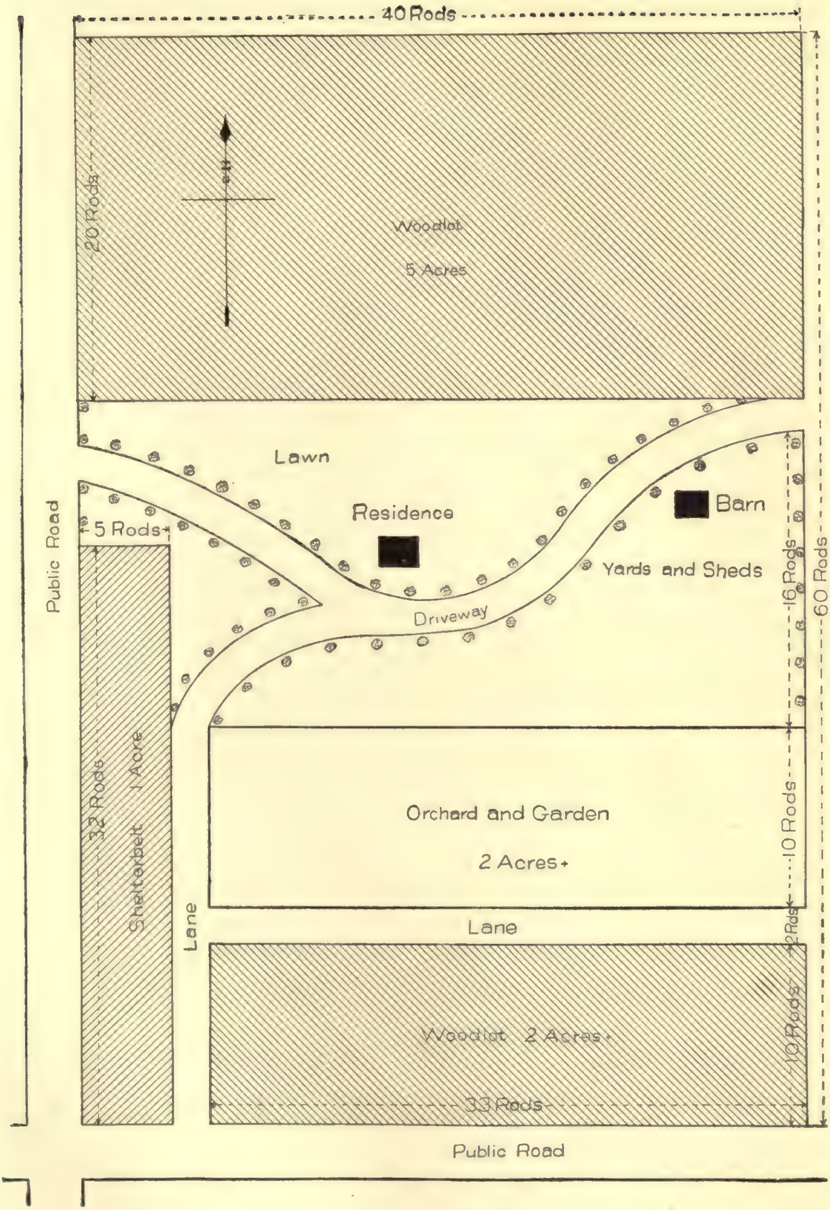
(9) Use perennial grasses, alfalfa, or clover in the rotation wherever practicable, and where it is impracticable to do so raise rye, peas, or sweet clover for green manuring to maintain the humus in the soil.

It is believed that the tentative conclusions drawn from the results of the investigations described here will materially aid in the establishment of rotations which will meet the above-mentioned requirements.—(Bu. Plt. Ind. B. 187.)

The effect of lime on the yield of corn is chiefly due to the fact that calcium carbonate (limestone) encourages nitrification (formation of available nitrogen) and the consequent liberation of the nitrogen and to a less extent of the phosphorus contained in the natural humus of the soil.

Pests.—The accumulation of noxious weeds, diseases, and insects on the farm is one of the most serious sources of loss, as already suggested. This results as a rule from the constant growth or too long continued culture of the same crop or class of crops on the same land. Cotton wilt, melon wilt, flax wilt, cowpea wilt, tobacco wilt, clover and bean anthracnose, root-knot worms, affecting nearly all crops except cereals, bacterial diseases of the tomato, potato, eggplant, cabbage, and numerous other vegetables, the grain rusts and smuts, and weeds and insects too numerous to mention all accumulate in the soil under the one-crop system.

These pests often multiply to such an extent that ultimately it becomes impossible to secure profitable returns from land thus infested, no matter how good the other cultural conditions may be. Resistant varieties must then be secured or crops cultivated on land not subject to these pests. All these troubles, however, can be avoided and the fertility of the soil greatly improved by intelligent systems of rotation. The most profitable systems for any locality or type of farming, so far as they have been developed, can usually be ob-



ARRANGEMENT OF WOOD LOTS AND SHELTER BELTS. DEPT. OF AGR.

tained from the state experiment stations or from the Department of Agriculture.—(Y. B. 1908.)

However efficient, in general, rotation of crops may be in the suppression of insect pests, the measure may easily be so applied as not only to prove ineffective, but actually disastrous. This is especially true in the change from a grass to a grain crop, and also in the process of breaking up and bringing under cultivation swamp lands, notably in the Middle West. The farmer who destroys the grass plants in his fields and in their stead attempts to grow Indian corn, by so adjusting his plowing and planting that the grasses are killed out, leaving the insects that feed upon them on the verge of starvation at the time his corn is pushing above ground, will find that he has made a serious mistake. A certain period of time must elapse between the destruction of the old and the starting of the new vegetation, in order to starve or drive out the insect enemies.—(Y. B. 1908.)

How Danger May Be Avoided.—In many portions of the Middle West a very large percentage of the annual loss to the corn crop by reason of insect attack is occasioned by this sort of a change from grass to a corn crop.

In the case of reclaimed swamp lands it is always best to plow during the summer, in the fall, and again in the spring before planting to corn. It is sometimes best to crop once with rye before attempting to grow corn at all. The reason for this is that the enemies of grasses and rushes growing in these lands before their reclamation will remain as long as this sort of vegetation exists, even to a limited extent, and if planted at once to corn they will attack this precisely as they do their native food plants, and destroy it. Very many serious losses have proven this to be true. On the other hand, where the reclamation has been completed before any attempt is made to grow corn on these lands, no such trouble has been experienced.

A precisely similar trouble is sometimes experienced with timothy meadows of long standing. An insect, commonly known as the bill bug, breeds in the bulbous root of this grass, sometimes in sufficient numbers to kill out the larger portion of it. The pest develops in the fall and remains in the field over winter to begin operations as usual the following spring. Now, if the infested field were to be plowed late in summer or early in fall the insect would probably abandon it, or, if not then, certainly in spring, as it could neither feed nor breed there; but if, as is frequently the case, plowing is left until spring and corn is planted soon afterwards, the insects transfer their attention to the corn, frequently killing the plants outright, and in other cases causing what is generally known as "frenching." This trouble is due to injury to the lower part of the stem, causing the plant to dwarf and throw up numbers of lateral shoots or suckers from the same root, no ears being produced. In the two cases just cited it is essential that the existing vegetation be entirely destroyed, thus either starving the insects or forcing them to abandon the field before the ground is planted to corn in spring.

Summer Fallow and Summer, Fall, and Winter Plowing.—These are all efficient measures in the extermination of injurious insects, the first being especially valuable in this direction, because it not only tends to exterminate all insect life in the fields thus treated, but prevents their becoming infested during the period of fallow. Next to this, in point of efficiency, might be placed midsummer plowing without further cultivation until fall plowing.—(Y. B. 1905.)

An increase in the number of bacteria in the soil means an increased available supply of plant food, hence the aim of a philosophical system in crop rotation is to include in that system such crops as favor the development of bacteria and the elaboration of plant food in the soil. Such crops are hoed crops, as potatoes, or forage crops, as clover.—(Del. Col. B. 40.)

Crops in their growth, it is now believed, have an important toxic (poisonous) reaction upon the soil in which they grow—that is, they give off from their roots during growth matter of a toxic or poisonous nature. Aeration, oxidation, and the chemical recombinations incident to the decay of organic matter are important aids in breaking up and removing these poisonous excretory compounds. Different classes of crops excrete somewhat different kinds of toxic matter. The crops in the rotation should therefore be so arranged as to prevent the toxic effects due to the continuous growing of the same crop.—(Y. B. 1908.)

Rotation for Tobacco Farms.—Crop rotation can also be made to serve a most useful purpose in many cases by preventing or minimizing the danger from insect enemies, especially those which spend a portion of their life cycle in the soil. Take, for example, the two greatest pests of newly set tobacco, and of many other crops for that matter—cutworms and the so-called wireworm, or stalkworm. Their presence depends almost entirely upon the character of the vegetation growing upon the land during the previous season; that is, whether it was attractive or not to the adult forms of these insects during the period when they deposited their eggs. To apply this principle, it is necessary to see that the soil is not occupied at the egg-laying season by vegetation which is attractive to the adult insect or, better still, to see that it is occupied by a form which is altogether repulsive. It is generally known by tobacco growers in many sections that after heavy growths of weeds, particularly the ironweed or stickweed, the soil is very likely to be seriously infested with the dreaded wireworm; indeed, it is frequently infested to such an extent as to render it almost impossible to secure a stand of tobacco until the pests leave or pupate, when it is too late to secure anything like a normal crop. A field intended for tobacco, or corn, or any other crop which these pests attack should not be allowed to grow up in ironweed during the previous year. A field which has grown cowpeas the previous season, provided they have been kept clean of weeds, will be free from both cutworms and the wireworm. This fact, if taken advantage of, is of inestimable value to tobacco growers, because the presence of wireworms or cutworms in the soil is a most serious drawback to any effort toward the increased use of fertilizers and the adoption of more intensive methods. It is a happy circumstance also for all dark types of tobacco—and these are types grown on soils most likely to be troubled with these pests—that the repellent crop is so desirable and valuable otherwise.

The feeding value of cowpea hay is very great, and the stubble adds much to the fertility of the soil. Increased quantities of ammonia tend to darken tobacco, and in cases where brightness is an important consideration, as in the bright-tobacco belt of southern Virginia, North Carolina, and South Carolina, the cultivation of cowpeas preparatory to tobacco might be objectionable.

The Effect on the Soil of Crops Available for Rotation.—The selection of standard crops generally regarded as adapted for cultivation on most tobacco farms in the export and manufacturing districts under consideration may be divided into four main classes: (1) The inter-cultivated crops, corn and tobacco; (2) the small grains, particularly wheat and oats; (3) the grasses, such as redtop and timothy; and (4) the legumes, including the clovers, vetches, and cowpeas.

In producing the inter-cultivated crops—corn and tobacco—the soil should be deeply broken and thoroughly aerated and pulverized. This is highly desirable, but, by hastening nitrification, oxidation, and decay, it serves also to use up the humus supply more rapidly. In the cultivation of the small grains, like wheat and oats, the soil is not so thoroughly and deeply broken and aerated. These crops are not so hard on the humus supply as tobacco and corn, but they are exhaustive rather than recuperative in their effect. The true grasses are similar to the small grains in that their cultivation is not attended with deep breaking and aerating of the soil and their entire plant-food requirements are extracted from the soil itself. There is this marked difference, however, in their effect upon the fertility of the soil: They occupy the soil continuously for two or more years, have a dense root system, and form a good sod, which, when turned under, adds materially to the soil's supply of humus, and during the period of their occupancy they hold the soil against washing and leaching. For these reasons they are to be classed as distinctively soil improvers.

The perennial clovers, such as red, sapling, and alsike clover, in certain respects might best be classed with the true grasses, but they have the additional advantage of being leguminous plants and are able to supply their requirements for ammonia from the air through the aid of the colonies of bacteria living symbiotically in the nodules which they form upon the roots. Their deep taproots also have a valuable effect not produced by the grasses in opening up and aerating the subsoil and in bringing up from the subsoil and utilizing plant-food material not accessible to many other classes of plants. The perennial clovers are often grown with the grasses, and when so grown the combination probably has few superiors in building up the fertility of the soil. The annual legumes, such as cowpeas, crimson clover, and vetch, also fix atmospheric nitrogen through the aid of bacteria on their roots, and the long taproots have a favorable action similar to the perennial clovers. Some of the annual legumes, like crimson clover and vetch, also occupy the soil only during the cooler months of the year, when they do not interfere with the growing of a regular summer crop. Cowpeas are especially valuable because they will produce a fair crop on a much poorer soil than will some of the other legumes and are a much surer catch under various conditions.

It is noteworthy that the growing of any crop of these four classes reacts upon the soil in a different way from any of the others, and each, except possibly the small grains, serves some particularly desirable purpose in soil improvement not so fully accomplished by any one of the others. It is desirable, therefore, that these different crops be grown in systematic rotation, so that the improving effects of each class may be regularly received and the ill effects of the exhaustive crops be systematically neutralized.

In placing the cultivation of the soil-improving grasses and clovers upon a successful basis at once the tobacco grower is greatly aided by the fact that his rotation includes a crop of such high commercial value as tobacco. There are but few general farm crops that will give profitable returns for applications of such large quantities of commercial fertilizers as will tobacco, and the after effects from this heavy fertilization are materially effective in insuring and increasing the success of the wheat, grass, and other crops succeeding the tobacco.

It is not practicable to attempt to lay out a rotation scheme adaptable to all tobacco sections, nor to all tobacco farms within a given section. The soil and climatic conditions of each section will necessitate modifications of any scheme that might be suggested, and the peculiarities of each farm, as well as the individuality of the farmer, will prove additional modifying factors. The important point, however, is that each farmer should study out for himself the best possible rotation for his own farm. So far as possible this rotation should include in systematic sequence all of the standard crops produced; and, under average conditions, the farmer will make a mistake if he does not include in that rotation enough of the soil-improving grass and leguminous crops to furnish a liberal supply of feed for live stock, so as to increase the available supply of barnyard manure and also by the stubble help to maintain the physical condition and bacterial activity of the soil at the maximum state of efficiency. Leguminous crops should be grown also with sufficient regularity to restore so far as possible the nitrogen removed by the nonleguminous crops.

Corn is a gross feeder and under the inadequate system usually followed it has not been considered advisable by farmers to grow corn in the same rotation with tobacco, because it so exhausts the soil as to materially injure the all-important tobacco crop. The result is that, except where there are lowlands or river lands unsuited to tobacco, the corn crop has been relegated generally to the poorer parts of the farm, which are thus made still poorer by continuous corn cropping; or, what is little better, corn is made to alternate with occasional resting years, when the land is given over to weeds and bushes. The result, of course, is a very poor yield of corn. However, with an adequate rotation system, including soil-improving crops, especially the legumes, it would be much better to include the corn in the general rotation unless there is sufficient river land unsuited for tobacco culture to grow all the corn necessary. By placing the corn crop in the general rotation on the better land of the farm the yield secured will necessarily be greatly improved; and, with the introduction of an intensive rotation system, together with a much heavier use of fertilizers on the tobacco, it may be found beneficial even to the tobacco by reducing excessive organic fertility, which would tend to make the tobacco coarse.—(Y. B. 1908.)

CROPPING SYSTEM FOR DAIRY FARMS.

Dairying is now the leading industry on many farms, especially in New England. In the main dairying has been a profitable business in New England. Taking the Northeastern States of the Union as a whole, owing to climate and topography the land is in general adapted to the growth of grass and trees. The fact that grass is so much at home in those States has led to a serious fault in New England dairy farming, namely, the mismanagement of grass lands. This consists in the main of a lack of proper treatment for permanent grass lands and of suitable rotations for other land, as well as the use for grass growing of land which does not give profitable returns from grass and which should rightfully be devoted to tree growth, either as woodland or orchards. Another frequent and widespread fault is the habit of cutting the hay crop entirely too late in the season, which of itself shortens the life of the meadow and results in an inferior quality of hay for dairy feeding.

Closely associated with poor management of grass lands is the failure to utilize other crops available for this section, especially corn. In southern New England there is little difficulty in growing good silage corn, but as one travels northward there is evidence of a lack of suitable varieties of corn for silage. This difficulty is not insuperable. There are varieties of corn that can be grown for silage in all but the most northern counties in New England. What is most needed is that sufficient attention be given to the selection of seed in order to develop strains of corn fitted to the requirements of the different sections.

A good cropping system for most of the New England dairy farms is the following rotation: Corn one year, peas and oats for hay one year; clover for hay two cuttings, one year; potatoes to sell, one year; Hungarian millet for hay, one year; timothy for hay to sell, two years, and then one year for pasture. This is virtually two good rotations, one following the other, the two covering eight years.

Another cropping system that has been highly recommended by good dairy farmers is corn for silage, one year; a mixture of peas, oats and barley for grain, one year; and hay, two years. The mixture of peas, oats and barley is threshed and ground and fed to any of the live stock as needed. Frequent plowing and the application of manure makes this a very profitable system.

A short rotation of three or four years, such as described, accomplishes three things. The first and most frequently recognized is the turning down of a good sod, especially a clover sod, every third or fourth year, a practice which furnishes a large supply of humus and fertilizing material, thereby producing larger yields of corn, small grains, or other crops. Secondly, the frequent breaking up of the sod, growing a tilled crop, and then seeding down again keeps up the yield of grass during such part of the time as the land is producing a hay crop. This increase in yield of hay is largely due to the clover, which can not be kept in the hay more than two years without reseeding, since it is a biennial. Thirdly, a short rotation permits the growing of some cash crop like potatoes on part of the land, and that without seriously depleting the soil, as is likely to occur when a crop of that kind is grown on the same lot continuously.

When land is suited to grass growing only, as is frequently the case with land in New England, either on account of being too moist or from having too many rocks at a short distance below the surface to allow frequent plowing, the problem of keeping up the yield is more difficult. The essentials in keeping up the yield of permanent grass land on a dairy farm in New England appear to be, first, the applying annually of small quantities of barnyard manure as a top dressing. Eight or 10 spreader loads per acre each season are much better than 20 or 30 loads every second or third year. If the farm does not have a manure spreader, it is somewhat more difficult to apply so light a coating, but when spread as well as possible by hand a brush harrow will break up the lumps and scatter them satisfactorily.

The use of a large proportion of clover seed when seeding down gives a better quality of hay for two years at least, and the clover improves the yield of the true grasses which are sown with it. Not only that, but it has been shown that the addition of small amounts of clover seed on top of the old sod in the spring is profitable.

It will be noted that with successful dairymen in New England one of the most general practices is that of cutting the hay crop early, which not only allows the cutting of a second crop, but gives a far better quality of hay for making milk. Two cuttings yield more and better hay than one late cutting. It may be well to explain that by early cutting is meant a time before any of the grasses or clovers in the mixture have had time to ripen and get dry and hard.

By practicing the fundamental rules in crop production just described, namely, the intelligent use of manures, the following of short rotations, and the good management of grass lands, many dairymen are already doing as much as can be done by the individual farmer toward solving the two obvious difficulties of getting the necessary concentrated feeds to supply protein in the feeding rations and of meeting the scarcity of farm labor. The first of these difficulties is remedied because the methods practiced result in a far more palatable as well as more nutritous quality of coarse fodder in the bright, early-cut hay, in the corn ensilage, and especially in clover and peas in the hay.

These last two classes of hay do a great deal toward supplying the protein of a dairy ration, and the small grain that is grown on several of the farms described supplies still more, whether it is fed in the straw, as the pea and oat hay of some of the farmers, or thrashed out. The cropping system followed on New England dairy farms is more or less applicable to such farms in other sections.—(F. B. 337.)

TOP-DRESSING GRASS LAND.

Grass lands require special fertilizer treatment. After the meadow has been established on land of good fertility and in good tilth and crops of hay are removed each year, the original supply of plant food is diminished and the productiveness of the meadow necessarily decreases. In order to maintain its profitable yielding capacity the supply of plant food must be kept up through fertilization. The method of applying fertilizers presents some difficulties which are not encountered in fertilizing the soil for most of the other crops. The grass remains upon the land continuously for a series of years and there is no opportunity for plowing under green manure or applying barnyard manure or commercial fertilizers and incorporating the same into the soil from the time one crop is removed until the succeeding one is put in, as can be done in the culture of annual crops. Furthermore, the coarser undecomposed material of barnyard manure which remains upon the meadow is likely to be raked up with the hay, which is a decided disadvantage, and the manure sometimes also has the effect of reducing the quality of the grass by causing a rank growth and by the introduction of weeds. The use of commercial fertilizers on meadows has the advantage of leaving the barnyard manure produced on the farm available for other crops, to which it can be more readily and satisfactorily applied. If barnyard manure is to be used on a meadow it should be applied as a uniformly fine and well-rotted compost.—(Rd. Id. B. 57, 71, 82, 90, 103; F. B. 222, 276.)

For different reasons given, and also on account of the greater availability of the plant food they contain, certain commercial fertilizers are better adapted to top-dressing grass lands than barnyard manure. The farmer must know, however, the kinds and quantities of fertilizers best suited for this purpose, at what time the application should be made, and whether under ordinary conditions he may expect a profitable return. These questions have been studied by the Rhode Island Station in an experiment extending over a period of six years, and the results obtained are here briefly summarized.

The experiments were begun in 1899 on three plats, numbered 17, 19, and 21. Since 1893 these plats had been devoted chiefly to the growth of leguminous crops and had received annually 180 pounds of muriate of potash and a quantity of phosphoric acid approximately equivalent to an application of 1,200 pounds of acid phosphate containing from 13 to 14 per cent of available phosphoric acid. During this same period plats 19 and 21 received each year

150 and 450 pounds of nitrate of soda per acre, respectively, while plat 17 received no nitrogen and had probably not received this element for from 15 to 20 years. In 1897 all plats were treated with 1 ton per acre of slaked lime. In 1898 7.5 pounds each of common red clover and redtop and 15 pounds of timothy per acre were sown, with barley as a nurse crop. The yields of hay obtained in 1899 were as follows: Plat 17, 5,075 pounds; plat 19, 6,300 pounds, and plat 21, 6,913 pounds per acre. The hay from the no-nitrogen plat consisted almost entirely of clover, while the crop from the other two plats was largely redtop and timothy. The results of this season indicated that large crops of grass require considerable quantities of immediately assimilable nitrogen applied early in the season, and that good crops of clover can be grown on limed land without supplying nitrogen in the form of commercial fertilizers. Allowing 20 per cent for shrinkage in the hay and estimating the value of the different crops at from $9 to $15 per ton, plat 17 gave a difference of $6.09 per acre over the cost of the fertilizer applied; plat 19 a difference of $14.34, and plat 21 of $19.62.

In 1900, soon after the grass started to grow, all plats received the regular dressing of potash, phosphoric acid, and nitrogen, but in 1901 the fertilizer application per acre was changed to 807.5 pounds of acid phosphate, containing 130 pounds of phosphoric acid; 200.52 pounds of muriate of potash, furnishing 100 pounds of potash, and 133.52 pounds of nitrate of soda on plat 19 and 400.56 pounds on plat 21, supplying 21 and 63 pounds of nitrogen, respectively.

Throughout the entire experiment plat 17 received no nitrogen; plat 19 a one-third ration, and plat 21 a full ration. The results obtained with the modified application emphasized the need of properly adjusting the quantities of the different elements given in the fertilizer application. The reduction of the nitrate of soda from 450 to 400.56 pounds and of the acid phosphate from 1,200 to 807.5 pounds and the increase of the muriate of potash from 180 to 200.52 pounds reduced the cost of the application and resulted in higher profits. The treatment of the plats in 1902 was essentially the same as the year before.—(F. B. 227.)

DRY FARMING.

Its Difficulties.—Dry land farming is a continual fight against relentless, unfavorable conditions. Success depends upon the man; his courage, his knowledge and judgment, and his persistence. Physical strength and endurance of both men and women is a large factor in this struggle. With the best seeds and methods of tillage there will be some years of total failure and many others of short crops. It is safest to lay plans that will furnish a living with an average of two failures each five years. There have been three consecutive years of no crops followed by as many years of good crops.

Conditions are much more favorable than they were twenty or even ten years ago. There has been no increase in the rainfall, but the methods of storing and holding moisture in the soil are better understood. Today there are dry land plants that will produce crops with limited rainfall and seeds of these crops that have been selected and bred under arid conditions. Thousands of failures have occurred that have been due to other than climatic causes. Men came and used seeds and methods adapted only to humid regions and persisted in the face of continuous failures until they lost their all.

No man should think of dry farming by what are generally considered improved methods as an indifferent or lazy man's job. Dry farming, to be successful and permanent, is necessarily good farming. The indifferent farmer will get a few good crops, many poor ones, and many almost complete failures. The man who has failed in a more humid region should not expect to succeed in the Great Plains. In a humid region any kind of cultivation is almost sure to bring some kind of crop, but not so in the dry country. It is only the best and most systematic farming that can be expected to give even moderate returns in unfavorable seasons, and in some seasons even this will fail.

Systems of Dry Farming.—For convenience dry farming may be divided into three main systems: 1. Crops annually,—a system whereby a crop, whether heavy or light, is grown every year. Probably crops may be grown every year with say 18 inches of rainfall, provided the proper methods are followed and the rainfall is properly distributed for storage and cropping. 2. Crops biennially,—a system under which crops are grown only every other year. In Utah yields of 30 bushels of wheat per acre have been obtained every other year with an annual rainfall of 12 inches and good crops biennially have been reported with an annual precipitation of only 8 inches. The soil was of an excellent character and the methods employed were up-to-date. 3. A modification or combination of the first and second. Under this class may be mentioned the production of two crops in three years, three crops in five years, or two crops in one year, one being a catch or cover crop, sown for its effect upon the soil or the soil moisture, to be plowed under before the regular crop is sown.

The system chosen for any section must necessarily depend upon a number of conditions, among which may be mentioned: The rainfall; the distribution of the rainfall; the length of the growing season; the general climatic conditions, such as the humidity of the atmosphere, the number of cloudy and clear days, the day and night temperature, and the windsweep; the elevation; the general aspect of the country and the farm; the character of the soil and subsoil; the depth of the soil and subsoil; the machinery available; and last but not least, the means for the disposal of the products.

There is a tendency of plants to adapt themselves to the climatic and soil conditions under which they grow. The native vegetation of arid regions have acquired certain characteristics and habits by reason of which they are able to flourish with a scant supply of moisture. The structure of the surface of the leaves and stems is such that they do not transpire as freely as plants growing in humid climates. The most striking characteristic, however, is deep rooting which enables them to draw moisture from a large area of soil and this is the main cause of their remarkable drought-resistance. The deep rooting is made possible by the greater permeability of western soils. The subsoil is not as raw and unproductive as in humid climates. There are of course exceptions such as shallow heavy soils. For the feeding area of the root to be limited by ground water near the surface is the exception.

It requires many years for crops from humid climates to adapt themselves to arid conditions, hence the farmer should take advantage of any strain or variety which has already acquired drought-resisting qualities. Home grown seed should always be given the preference. We now have varieties of wheat grown in the intermountain region for 25 years or more and these are thoroughly acclimated.

General Observations.—Success is more likely to follow the careful selection of crops adapted to dry land conditions than to promiscuous planting of seeds, regardless of capacity to withstand conditions imposed. Among the qualities desirable are hardiness and ability to survive severe winter weather unprotected, drought resistance structurally capable of living in dry atmosphere without undue transpiration of water. The cactus is an example of great drought resistance. Plants with small leaf surface are less likely to suffer in a dry climate. Early maturity enables the plant to mature its seed before the pinch of drought overtakes it. Generally early maturing varieties are best suited to a dry climate. Deep rooting habits are more favorable than superficial root systems. Alfalfa and other deep rooting plants avail themselves of moisture to great depths and may even find perennial success of subterranean water. Such plants are affected least by the drying out of the surface soil. Plants that remain dormant during drought and do not die but start into growth with new supplies of moisture are of great advantage.

For dry farming use seed grown on dry land; never seed from humid climates or grown with irrigation. Early maturity is an advantage and that characteristic should be sought for in dry land crops. In seeding wheat or other cereals on dry land only half as much seed should be used as in humid climates or on irrigated land.

Moisture Conservation.—The first great consideration in dry farming is to conserve the moisture. As a rule, the soil is fertile enough and the one thing lacking is moisture to make the plant food in the soil available; and as there is a deficiency in the precipitation, the soil moisture is the main reliance of the plant.

The dry land farmer must continually bear in mind that in order to succeed, he must study the physical characteristics of his soil and take advantage of every possible means of conserving all the moisture that falls, whether it comes during the preparation of the land for seeding, during the growing period of the crop, or after a crop has been harvested. The foundation principle of conservation of moisture is to provide and maintain at the surface a layer of loose soil which serves to prevent the escape of moisture by evaporation. In the majority of cases, it will be necessary to conserve the moisture of two seasons for a single crop; and early deep plowing, summer tilling of the land, and so arranging the crops that two seasons' rainfall will be largely utilized for each crop, are the means of securing the desired results. The dry land farmer cannot afford to be at all careless about any of these operations. He should also remember that every weed allowed to grow in his cultivated crops saps its proportion of the moisture from the land and thus robs him of a portion of his just dues.

Usually in discussing dry-farming conditions the annual precipitation is the only feature of the rainfall that receives attention. But there are other factors in connection with the rainfall that have much to do with the successful production of crops. The seasonal distribution of the rain, the rate at which the rain falls, and the amount of rain that is lost through run-off from the surface all have an important part in determining the percentage of the total rainfall that is really available for the use of crops. Finally, the amount of evaporation which takes place during the growing season determines to some extent the amount of rain that is needed to produce a crop, and this varies greatly in different localities.

Classification of Dry-Farming Regions.—Dry-farming regions are naturally classified on the basis of rainfall. In this country dry farming is usually considered to be confined to those regions in which the annual rainfall is less than 20 inches and more than 10 inches. This classification must be considered as only a rough approximation, since dry-farming districts can not be outlined on the basis of the annual rainfall alone on account of the great influence of the evaporation and the monthly distribution of the rain in growing dry-farm crops. Furthermore, it is impossible to say just where ordinary methods of farming leave off and dry-farming methods begin. Dry-farming methods are usually understood to mean those which lead to the conservation of moisture, but the conception of what these methods actually are varies greatly in different sections of the country. The dry farmer in the Great Plains, where the rainfall is from 15 to 20 inches, usually gets his best results with annual cropping methods combined with good tillage. On the other hand, the dry farmers in that part of the Great Basin where the rainfall is less than 15 inches follow the method of alternate cropping and summer tillage almost exclusively. Between these two classes there is a third operating under conditions where summer tillage may be necessary to insure returns on every crop, but where it frequently pays to take chances on producing a crop on the land each year.

The method of alternate cropping and summer tillage is generally recognized as the most highly developed dry-farming method because it gives better returns with a lower annual rainfall than other methods. There are considerable areas in central Utah that are cultivated in this way where the annual rainfall does not exceed 13 inches. It must be remembered, however, that this is a region of winter rainfall, and that the method of alternate cropping and summer tillage is particularly adapted for such regions. Therefore, while the method of alternate cropping and summer fallowing is recognized as the most highly developed dry-farming method, it does not follow that it is the best method for all dry-farming sections or that it will always give the best returns. In dry-farming sections where the rainfall is not so limited as in Utah, and especially in regions having a summer rainfall, other methods give as good or better returns.

Importance of Knowing the Normal Rainfall.—The rainfall in all parts of the United States is subject to wide fluctuations from year to year. The West does not appear to be more subject to these changes than the East, but the fluctuations are felt more by the dry farmers because they are working upon a closer margin. Crops in the East are often lost through drought and not infrequently under conditions where the up-to-date dry farmer would have produced a good crop. On account, then, of the fluctuations in rainfall in any locality from year to year, it is necessary in judging the rainfall of a region to know the average annual rainfall, or, as it is called, the normal rainfall. This is the only safe basis upon which the rainfall of any region can be judged, and the longer the records the greater is the dependence that can be placed upon the normal. While two years' or three years' observations are safer than a single year's records, it is not uncommon for two or three wet years or for two or three dry years to follow one another in succession, so that the yearly rainfall obtained at such times would be too high or too low. Records for at least five years, and preferably for ten years, are necessary to obtain the normal rainfall of a region, and the longer the records the more reliable will be the result obtained.

In studying the rainfall of a region too much dependence must not be placed upon the records of a single station, especially if this station is located in a mountainous region. Under such conditions marked differences in the annual rainfall are often found between stations located on the highlands and those in the valleys. The cooling of the moisture-laden air through expansion as it rises over a range of hills causes precipitation, so that the windward sides of mountains have a greater rainfall than the leeward sides. This is well illustrated in the very heavy rains which occur all along the west slope of the Cascade Range in Washington, Oregon, and northern California, while the rainfall on the east side is very much less. This is also well illustrated in Riverside and San Bernardino counties in southern California, where a great change in rainfall occurs as we go eastward a few miles.

These sudden changes in normal rainfall are not, however, confined to the mountainous regions; marked instances of this kind occur in the Great Plains, where changes in elevation are comparatively slight. For example, the rainfall in the district around Aberdeen, in Brown County, S. Dak., is nearly 5 inches above that of the surrounding section. This difference is based upon observations extending over twenty years or more; and the effect upon the crops has been so marked that the farmers generally recognize that good crops may be found in this section when the surrounding regions are suffering from drought.

The monthly distribution of the rainfall in the Western States can be divided roughly into three types—the summer rainfall of the Great Plains, the winter and spring rainfall of the Inter-mountain district, and the winter rainfall of the Pacific Coast region. In the Pacific Coast region the rainfall occurs almost entirely during the winter months, and the summer months are very dry. In the Inter-mountain region the maximum precipitation occurs during the late winter and spring months.

In the Great Plains the monthly distribution of the rainfall is quite different from that of the Intermountain region, the greatest monthly rainfall occurring in June, July and August. Summer tillage for moisture conservation is not so well adapted to this region. The frequent rains during the summer months repeatedly pack the surface mulch on the summer-tilled land. This requires frequent cultivation in order to avoid the loss of water by evaporation, and so increases the expense of maintaining the mulch. Owing to the high evaporation in the Great Plains during the summer months, very little water will be stored in the summer-fallowed land unless the mulch is carefully kept up by thorough cultivation after every rain. The higher annual precipitation in the Great Plains and the increased cost of maintaining a good mulch on summer-tilled land have thus combined to make summer fallowing in this region much less popular than in the Great Basin country. Furthermore, the blowing of the dry surface mulch of the summer fallow sometimes becomes very serious in the Great Plains owing to high winds.

For the above reasons annual cropping is largely used in preference to summer tillage in the Great Plains, although in some parts of the area summer-tillage methods are considered necessary to insure sufficient moisture, even at the cost of the increased labor necessary to maintain the surface mulch. Spring grains are generally used under the annual cropping method, since the crop escapes the dry fall and winter, and the land, having been recently worked, is in the best condition to absorb the summer rainfall. The shade of the growing crop partially protects the ground from excessive loss of water by evaporation, while the small summer showers that are useless on summer-tilled land always help the growing crop. Thus we have a radically different system of farm practice in the Great Plains from that found in the Intermountain country, owing in part to the difference in the distribution of the monthly rainfall of the two regions and in part to the greater rainfall in the Great Plains.

The way in which the rain comes has a great deal to do with its usefulness. Summer-fallowing methods, for example, are not well adapted to regions in which the rainfall comes largely in the form of little showers from one-tenth to one-half inch. Rains of this kind penetrate the soil only a few inches, and the water is practically all lost through subsequent evaporation even when the surface of the soil is cultivated after the rain, since the rainfall does not penetrate below the depth of the mulch. These small rains are, however, usually sufficient to pack the mulch and form a surface crust, which must be broken by cultivation as soon as possible; otherwise, evaporation will go on so rapidly from the surface of the soil that far more moisture will be lost than was gained through the rain.

Retaining Moisture in the Soil.—When dry land soil has been loosened to a good depth to form a reservoir, and it is porous and fine grained, the water from a rain slowly moves downward through it until absorbed, and each minute grain of earth becomes covered with an invisible film of moisture.

When these minute grains of soil are in close contact with one another, there is a constant movement of the water in the films surrounding them, the water flowing from a wet grain to a dryer one. After a rain the sun and the wind dry out the surface soil and carry away the moisture contained in it. Then the water from the damper soil below moves upward to wet the surface grains and is in turn evaporated. This movement continues in land not cultivated and extends to a depth of many feet, often, in a dry time, taking out of the soil in a week moisture equal to more than an inch of rainfall.

When the surface soil is stirred after a rain, the tiny grains are separated so that the water does not easily pass from one to another. The movement of the moisture is checked and evaporation is greatly reduced. Such shallow cultivation is called an earth mulch, because it has a similar effect in holding the moisture in the soil as that effected by a mulch of straw or a covering of boards.

The dry land farmer's supply of moisture for his crops depends upon his skill and judgment in maintaining an earth mulch over his cultivated fields. No set rules can be given. He should study the principles governing the absorption and movement of water in the soil, as here given, until he thoroughly understands and appreciates them. Then he can intelligently conduct the farm operations for maintaining the earth mulch. The deeper the earth mulch, the better it will prevent evaporation from the soil. For cultivated crops a general rule, with many exceptions, is to keep the mulch three inches in depth. With trees, four to six inches is better. Seeds must be planted below the earth mulch so that they will be in moist soil and the mulch must not be so deep as to prevent the young plants from coming up. With growing wheat and other grains, the mulch must not be made so deep as to put the roots in dry soil.

A good rain packs the loose surface soil and destroys the earth mulch. It is necessary to pulverize the ground quickly after every such rain to restore the earth mulch, as a week's delay may mean the loss of water equal to an inch of rainfall. Light showers do not usually destroy the mulch.

On account of the winds, evaporation is very rapid just after the frost goes out of the ground in the spring and an earth mulch should be established as soon as the ground is dry enough to work. Evaporation is very rapid from stubble fields after the grain has been cut, and an earth mulch should be made with a disc harrow as soon as the grain is shocked. Where the surface is hard, the earth mulch will have to be made with a disc harrow; where the surface is mellow, a spike toothed harrow will pulverize the soil sufficiently. A four-horse disc harrow should be used for economy of time. A man having five horses attached to a twenty-four foot spike tooth harrow can put a mulch on thirty to sixty acres a day.

When the annual rainfall drops much below twelve inches and the rainfall during the growing season below five inches, it is difficult, and often impossible, to raise a profitable crop. The land can be fallowed one season and cropped the next, the one crop having the use of what moisture can be stored from two years' rainfall. During the season that no crop is raised an earth mulch must be maintained, and to do this it is usually necessary to till the surface about every ten days, and always after any considerable rain. In many seasons paying crops may be secured by this system, where, if an attempt is made to grow crops every year, the failure will be total for both years. With this system the dry land farmer who has one hundred and sixty acres under cultivation will each year have eighty acres in crops, and eighty acres which he will have to till regularly, but upon which nothing will be growing.

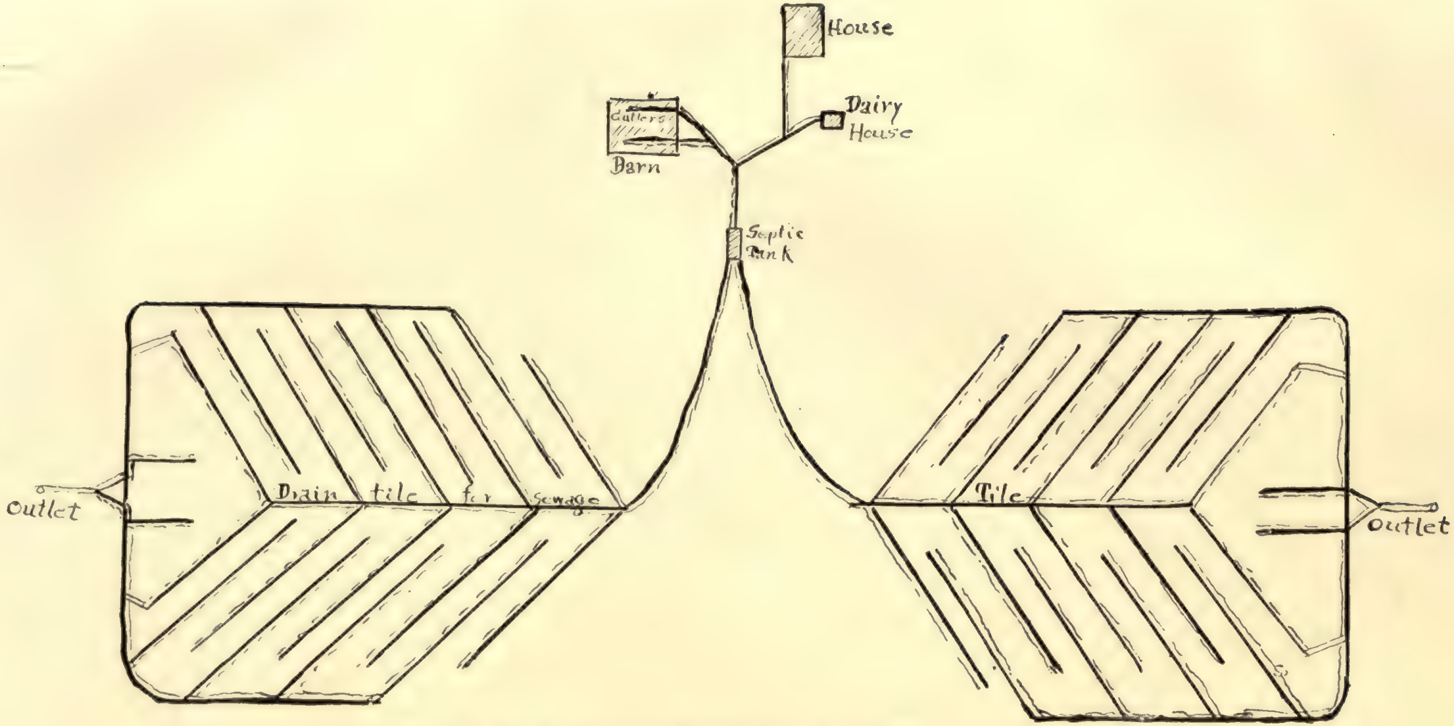
Conservation of moisture is not the only benefit derived from summer tillage, although it is one of the most important reasons for the good results following. Such tillage puts the ground in very much better physical condition for plant growth, aside from the more favorable moisture content. There is abundant evidence also that there is more available plant food in the upper layers of soil and within easy reach of the plant roots. This, however, must not be interpreted to mean that fertility has or has not been added to the soil. The temperature and moisture conditions secured by the clean and thorough cultivation given are favorable for changing the condition of the plant food already in the soil so that plants may use it, while it was previously in unusable form.

Summer Tillage.—One of the very important effects of summer tillage on winter wheat is that it enables the wheat to start at once with a vigorous growth and so enter the winter in good condition. It thus comes through the winter strong, well rooted, and ready to take advantage of any opportunities for growth. In this condition it is able to withstand considerable hardship, when wheat on land less thoroughly prepared suffers in the winter and comes through weak or dies. It will often happen that the field which was summer-tilled the preceding season will contain little, if any, more moisture in the spring in the first 3 feet of soil than a field which grew a crop and was plowed and seeded to wheat, but the wheat on the summer-tilled land will have so much better start that it will go on and make a crop under conditions that would cause the other to fail. It appears also that grain on summer-tilled land, either by virtue of better root systems or because of the better capillary condition of the soil, is able to draw water from a greater depth. Summer-tillage is not practicable on all soils nor for all crops. Soils which are likely to blow, especially very sandy soils, can not be bare tilled because they will blow away.

Summer tillage will almost invariably increase the yield of wheat, oats, or barley and will materially reduce the danger of complete crop failure due to drought. It may therefore be resorted to as a safeguard or temporary expedient to meet a possible emergency, but it can not be depended upon to produce as profitable spring-sown crops as may be produced by other methods. Very good crops can usually be raised by one plowing and one or two harrowings, as is shown by yields obtained from continuous cropping by ordinary methods. Alternate cropping and summer tillage by methods used in these tests required on an average two plowings, four diskings, and twelve harrowings. Each farmer must decide for himself whether he can afford to perform this additional amount of labor in order to secure an increase in yield, which if the season proves favorable may be small, and to materially reduce the danger of total failure if the season proves unfavorable. He should, however, remember that summer tillage will in no way reduce the many dangers other than drought, such as unseasonable frosts and high winds, to which crops are subject. In fact, these dangers may be materially increased under a system of summer tillage.

Dry Farming Crops.—There is quite as large a range for adaptation, amelioration and breeding with dry farming crops as with those grown under humid conditions. The necessity for such effort is far more urgent, and the reward quite as promising. Crops must be selected or developed that will fit the environments, and there seems to be quite as large a field for investigation in the improvement and development of crops suited to the various conditions in the dry farming sections as in the improvement of methods of handling the soil. In other words the pedigree of the seed is quite as important as the cultural methods. Neither should be neglected. If the rainy season is short, early maturing crops must be selected, those having a short period of growth. If the rainy season is preceded by a rather long period when the moisture content of the soil is rather low in spite of the means employed to increase it, then crops should be chosen that will make the necessary early growth with a minimum amount of moisture and later be pushed forward to rapid maturity when the rainy season sets in. Still other crops or strains of seed must be selected wherever the moisture content of the soil is ample throughout the growing season. Under such a condition it would be quite useless to grow crops bred for and adapted to a very short season's growth. The dry farmer must not neglect the cultural methods, but he must not be tied to the idea that the way in which the soil is handled is the only essential. The kind of crop and the class or strain of seed used are factors which ultimately will have much to do with the result.

It has been demonstrated by repeated experiments that crops can within certain limits be adapted to new and different environments. Aquatic plants in time have adapted themselves to and become dry land plants. So to, plants that for centuries have grown in conditions of abundance of moisture, have gradually become adapted to conditions where there was very decidedly less moisture.



SEWERAGE AND IRRIGATION SYSTEM FOR A FARM. DEPT. OF AGR.

(See pages 258–276.)

This very wise provision of nature supplies the means whereby man is able to transport and adapt crops to new and heretofore untried conditions. He is only barred in his progress by the limitations nature has set.

There is little doubt but that strains of seed of certain crops which have been successfully grown for years under trying semiarid conditions will be in great demand. As a result of this demand we may reasonably expect pedigreed dry farm crops to appear and they will fill an important want.

To give a list of crops suited to dry farming for all sections and conditions is practically impossible. Crops that are well suited to a certain class of conditions would be wholly unsuited to another. Therefore, the following brief list must be considered only as suggestive:

Cereals.—Wheat stands at the head among the cereal crops for dry farming areas and it probably stands at the head of all crops for this purpose when everything is considered,—adaptability to dry farming conditions, cost of production, profits, etc. There are certain classes of wheats that do best under drouthy conditions. The durum or macaroni wheats seem to do exceedingly well when compared with other classes, yet there are varieties among other classes which also do well on dry farms. Spelt, oats, rye and barley are all used on occasion. Barley is probably the poorest crop mentioned because it is comparatively a shallow rooted crop and for this reason, likely to prove less valuable than a crop which forages more deeply for its food.

Sorghums.—Both saccharine and non-saccharine sorghums are grown. Fodder cane, kafir corn, Jerusalem corn and doura belong in this class. They should be sown for hay with a hoe drill or planted with a corn planter and cultivated. The sorghums may also be double rowed, i. e., planted in groups of two rows about eight inches apart and cultivated.

Millets.—Among the millets are found some of the most paying dry farm crops. Some of them grow and mature with a remarkably small amount of moisture present in the soil and at the same time the period of growth is very short.

Legumes.—There are a few legumes that have shown value as dry farm crops. Peas, beans and alfalfa are the most promising although in order to secure a stand of alfalfa it will very probably require summer fallowing one year in order to accumulate sufficient moisture to insure perfect germination. After a stand is secured alfalfa has given good results in some sections. The alfalfa should be sown with the hoe drill and rather deeply for such small seed.

Vegetables.—Garden vegetables form an important group. They add so greatly to a bounteous table supply. Many vegetables grow to the proper stage for consumption in a few weeks, and therefore, are surer than almost any other class of crops. If markets are available they may be made a source of considerable revenue.

Trees.—Both fruit and shade trees are grown in districts where dry farming is practiced. The home surroundings may be made more comfortable and greatly improved in appearance by the free use of shrubs and trees. The same care, however, must be exercised in the selection of the kinds to plant and in their care as is used with field crops. The first two or three years, until they become deeply rooted, is the most critical period in the life of a tree or ornamental shrub. Cultivation during that period should be constant and thorough.

Crops.—The dry farmer, more than the humid land or irrigation farmer, must select and grow crops adapted to his local conditions. The developing of varieties capable of contending with aridity is progressing rapidly. Rotating of crops, conserving and utilizing of farm manures, and maintaining a full complement of livestock are essentials to the highest degree of success in dry land farming.

Earliness.—The two principal reasons for desiring early varieties are, first, to extend the range of grain sorghums into dry regions having a short growing season; and, second, to obtain the fullest possible benefit from the seasonal rainfall, which comes largely during the early summer months in parts of the grain-sorghum belt. This second reason is thus connected with the problem of drought resistance, though, as pointed out, earliness is a means of drought evasion, not of resistance.

Late varieties of milo do not mature. At lower elevations their present range extends northward into southwestern Nebraska. In northern Nebraska, the Dakotas, Montana, and Idaho the increasing latitude and shorter growing season prevent their successful maturing. It seems certain, also, that the soil, especially at night, is too cool to permit vigorous growth, thus retarding the maturing of the plant even where the season is otherwise long enough.

Improvement in earliness will need to be continued for a long time if varieties are to be perfected for the needs of all the dry-farming regions.

Early Varieties.—The milos are much earlier varieties than the kafirs, and are very promising material on which to work. In the Panhandle of Texas, at elevations of 3,000 to 4,000 feet, they now mature in ninety to one hundred days when sown May 15 to 20. At present they are grown successfully at altitudes between 4,000 and 5,000 feet in Texas, New Mexico, and Colorado.

Earliness can be developed only by continuous selection. Such selections can be made either at heading time or at the time of ripening, but are preferably the results of records made at both periods. When the field or seed plat of the variety begins to head, a number of the earliest heads which are otherwise suitable for selection should be marked by means of tags on which is recorded the date of heading. When the heads on these selected stalks begin to show the characteristic colors and texture of the hard dough, or ripening stage, the date of ripening should be added to the tags. Other things being equal, those heads for which the shortest time has elapsed between heading and ripening are to be considered the earliest. These heads should be carefully saved separately and used for continuing the work another season.

In dry regions, where the amount of moisture in the soil is commonly the controlling factor in crop growth, the plants at the ends and sides of a field are often the first to produce heads, especially in dry seasons. This is because the outside plants have a larger area from which to draw moisture, or because run-off water often collects at the edges of fields and provides extra moisture.

It is imperative that the seed should be grown under arid conditions. It is best to use seed that has been grown in the neighborhood where it is to be planted. If this is impossible, the seed should be grown under as dry conditions as will be met by the growing crop. This fact can not be emphasized too strongly. Even a small increase in the amount of moisture will lessen the power of plants to withstand severe drought.

It is the common practice for new dry land settlers to bring their favorite seeds with them. The Iowa man brings seed corn, the Indiana man oats, and the Michigan man potatoes. With seasons of average or lower rainfall, the planting of these eastern seeds guarantees a failure. The root development of plants from eastern seed is not sufficient to enable them to spread far enough in dry land soil to gather enough moisture, and often the too great growth of foliage evaporates too much moisture.

Only those grain crops that mature early, before drought and hot winds come, and before the spring moisture is exhausted, should be grown. Wheat, barley and speltz are such crops. The surest forage crops are those like sorghum, milo maize and kafir corn that live and stand still through a drought and then mature quickly when rain comes. Seed should be selected from plants whose large root systems give them a broad area from which to draw moisture.

Every season it is likely that conditions will be unfavorable before the season is over. This condition demands seed with strong vitality that will transmit vigor to the young plants as soon as they start. Heavy seeds, as a rule, give strongest growth and the thorough use of a fanning mill with plenty of air is a great aid in securing a crop. Dry land farmers are usually careless about seed and use a mixture of heavy, shrunken and cracked grains, weed seed, chaff, sticks and dirt. There is much loss from seed that has been heated. Thin seeding is necessary. Where there is moisture enough to mature one plant only, if two occupy the space, the crop is a failure. When in doubt about the quantity of seed needed, use one-half the amount customary for humid sections. The following pounds per acre are suggested, but the amount should vary with the size of the seed and the condition of the soil:

Wheat, 30 to 40.
Barley, 35 to 50.
Speltz, 45.
Flax 20.
Millet, 10.
Sorghum drilled for forage, 25.
Kafir corn, drilled for forage, 25 to 30.
Milo Maize, for grain, 5 to 8.
Corn, single seeds, 15 to 18 inches apart.
Dwarf Essex Rape, 3 to 5.
Brome Grass, 20.
Alfalfa, for hay, 12 to 20.
Alfalfa, cultivated for seed, 2 to 3.
Sweet Clover, 20 to 25.

Early seeding should be the rule, so as to take advantage of the moisture released when the ground thaws out and from that furnished by early rains. The development of the native vegetation is a good guide to the time for seeding. Broadcasting has no place in dry land farming. It is a sure method of wasting seed and of producing many weak plants. Some seed is certain to be put in too deep and more too shallow. All seeds should be drilled and great care should be taken that single seeds are placed at equal distance apart. In careless drilling, where seed is bunched, there is not enough moisture to develop the plants, and the moisture in the bare spots is wasted.

Cultivation.—Plowing is the most important factor connected with dry farming operations. If the plowing is not properly done an adequate water reservoir will not be formed in which to store the rain or snow fall. Should this feature of the work be neglected much of the rain and melting snow will run off from the surface of the ground and be lost instead of sinking into the soil, there to be stored.

Plowing, if possible, should be performed when the soil is fairly moist, so that it will come up mellow and can easily be leveled and fined. Discing immediately after the crop is removed will aid materially in this respect. The character of the soil and the season of the year will largely determine the depth to which it is best to plow. Usually the plowing should be from 8 to 12 or more inches deep if done in the fall, obviously somewhat shallower if done in the spring.

The subsoil plow may follow the plow if after due trial upon small areas it proves beneficial upon that particular soil and subsoil and under the conditions prevailing. The plow should be followed by the sub-surface packer, especially if the plowing has been very deep. If a sub-surface packer is not available the field should be run over with the disc set straight but well weighted down. The sub-surface packer should be followed by the acme harrow or toothed harrow, thus thoroughly pulverizing and fineing the surface so as to form a good mulch and at the same time provide against any surface run-off of the water that subsequently falls.

The sub-surface packing and the formation of a surface mulch should be performed each half day. If the soil is left loose and a large surface exposed to the air for only a few hours, large quantities of moisture will be evaporated, pass off into the atmosphere and be lost to the crop. Success often lies in the proper performance at the right time of these seemingly insignificant operations.

The character of the cultivation practiced in the semi-arid belt should be such as to put the soil in the best possible condition for plant growth and at the same time conserve the greatest possible amount of soil moisture.

Experiments, often repeated, have proven that the evaporation of moisture from a soil surface is least when that surface is least exposed to the air. It follows, therefore, that any irregularities in the surface increases the surface exposure, which in turn increases the evaporation of moisture. The reason for laying so much stress upon following the plow immediately with the harrow is to prevent the loss of moisture from the irregular surface. Level culture with a fine even surface has proven the best method for conserving moisture and for most crops this condition is the most favorable for root development and expansion. There may be conditions of a peculiar nature where this rule will not hold good, though it is difficult to think of such a condition.

Level culture should mean not only a level surface exposure when the work is completed but it should also be made to mean the cutting or stirring of a slice or layer of the surface to practically the same depth at all points. This is usually best accomplished by using a long, flat blade which is run so as to cut an even depth and at the same time stir the soil before it falls back in position. Another means almost as effective is the use of a large number of small shovels. Even small shovels leave an uncut ridge underneath, and a slight corrugation on the surface. Large shovels are extremely harmful since they leave the surface in great ridges and portions of the uncut under-surface exposed to the air.

Seeding.—All seeding and planting should be done with a machine that will deposit the seed in the moist soil at an even depth and leave a loose surface over it. The depth at which the seed should be sown will vary with the size and viability of the seed quite as if sown under humid conditions, but in dry farming the seed must be deposited not a certain depth below the surface of the soil, but a certain depth below the top of the moist soil. This is an important point. Not infrequently, deep planting will be required, but there is little danger in planting deep under dry farming conditions for the reason that the young plants readily push to the surface through the loose dry surface mulch. Should the seed be deposited in the dry surface mulch it will lie there until a shower comes or until the moisture from below is brought up to it by rolling or other similar treatment.

Pure Seed.—The profits of dry-land grain production are much increased by using only pure seed, and a great many failures are due to the use of inferior varieties or impure seed. If the seed planted is of more than one variety, losses are likely to follow on account of irregularity in the time of ripening, which results in the shattering of large quantities of the early-maturing grain. Furthermore, mixed grain is never as likely to command top prices as grain of one variety. The inadvisability of planting grain containing weed seeds is too well known to require extensive discussion. In selecting seed grain the farmer should obtain the best-known variety grown in his locality or in a locality of similar conditions. He should see that the seed is as nearly as possible of one variety and that all weed seeds and light or shrunken kernels of grain are removed from the seed before planting. The cleaning is quickly and easily done by the use of a common fanning mill, which can be purchased for about $40. This simple machine should be included in the equipment of every grain farm.

Rotation.—All crops may be classified under three heads: Exhaustive, intermediate, and restorative. No crop restores to the soil any very considerable amount of plant food unless it is plowed under for green manure, or is allowed to decay on the surface. In dry farming a rotation of crops is absolutely necessary. The following five and six year rotations have been found to work well in the Great Plains area.

Five Year Rotation.

Corn. Wheat, winter or spring. Brome-grass meadow. Brome-grass meadow. Oats, barley, emmer, or wheat.

Wheat, winter or spring. Brome-grass meadow. Brome-grass meadow. Oats, barley, emmer, or wheat. Corn.

Brome-grass meadow. Brome-grass meadow. Oats, barley, emmer, or wheat. Corn. Wheat, winter or spring.

Brome-grass meadow. Oats, barley, emmer, or wheat. Corn. Wheat, winter or spring. Brome-grass meadow.

Oats, barley, emmer, or wheat. Corn. Wheat, winter or spring. Brome-grass meadow. Brome-grass meadow.

Six Year Rotation.

Corn. Wheat, winter or spring. Seeded to brome-grass. Brome-grass meadow. Brome-grass meadow. Oats, barley, emmer, or wheat.

Wheat, winter or spring. Seeded to brome-grass. Brome-grass meadow. Brome-grass meadow. Oats, barley, emmer, or wheat. Corn.

Seeded to brome-grass. Brome-grass meadow. Brome-grass meadow. Oats, barley, emmer, or wheat. Corn. Wheat, winter or spring.

Brome-grass meadow. Brome-grass meadow. Oats, barley, emmer, or wheat. Corn. Wheat, winter or spring. Seeded to brome-grass.

Brome-grass meadow. Oats, barley, emmer, or wheat. Corn. Wheat, winter or spring. Seeded to brome-grass, Brome-grass meadow.

Oats, barley, emmer, or wheat. Corn. Wheat, winter or spring. Seeded to brome-grass. Brome-grass meadow. Brome-grass meadow.

It is assumed that the corn crop will produce enough in the form of fodder and grain to at least pay for the labor involved in its production. The labor involved in raising a crop of corn is no greater than that required to summer till an equal area. In comparing the yields obtained from the small-grain crops in a rotation containing summer tillage with one containing corn it has been assumed that the yields from the summer-tillage rotation must be enough in excess of those from the corn rotation to pay for the summer-tillage. Or, to put it in another way, the corn crop must be sufficient to equal in value the excess in yield of the two small-grain crops in the summer-tilled over those in the corn rotation. Whatever form of comparison is used it is assumed that the labor required to produce a crop of corn is approximately the same as to summer till. The corn crop pays for the work bestowed upon it, while the summer-tilled rotation must produce enough more small grain to pay for the cost of the summer tillage.

Corn should therefore be much more commonly grown than it now is in this area, not because it is a profitable crop in itself, but because it takes the place of summer-tillage in the rotation and at least pays for the labor bestowed upon it. A corn crop might therefore be considered a complete failure judged from the standpoint of grain production, but still yield enough in the way of rough fodder and be valuable enough in its effect upon subsequent crops in the rotation to make it a very profitable crop.

Sorghum.—The grain-sorghum belt, broadly speaking, is the southern half of the Great Plains region, nearly 400 miles wide and 1,000 miles long. It is characterized by low rainfall and high evaporation, by varied soils and considerable elevation, with correspondingly shortened seasons. It is fitted to become a noted stock-feeding region.

The grain sorghums, including milos, durras, kafirs, and howliangs, are of recent introduction and have become important only within the last twenty years. By their earliness, drought resistance, and adaptability they are especially fitted for growth under Great Plains conditions. The grain is largely used for feeding stock on the farms where grown. Its feeding value is nearly equal to that of corn. The protein content averages higher than that of corn, the fat and fiber content lower. Any surplus is readily marketed as whole grain or as chops for feeding purposes. It is in much demand for poultry food, for which it is admirably suited. Over 25 per cent of the ingredients of prepared poultry foods in the eastern United States is kafir grain. It seems probable that the meal can be used as readily as corn meal for human food and that both the meal and flour can be used in mixtures with wheat flour.

Kansas and Oklahoma grow annually over 1,250,000 acres. It is probable that an equal area is also grown in Texas. The grain-sorghum acreage in Kansas is nearly 10 per cent of the corn acreage, and in Oklahoma over 12 per cent. More than half the kafir and over 95 per cent of the milo are grown on the dry lands west of the ninety-eighth meridian. In this region the proportionate acreage to grain sorghums to corn is steadily increasing. In spite of the less favorable conditions under which much of the crop is grown the average acre value of the grain sorghums in Kansas is higher than that of corn, and in Oklahoma it is 70 per cent as great.

The grain sorghums may be greatly improved through the selection of better varieties and the use of better methods. Improvement will be chiefly in the direction of (1) drought resistance, (2) earliness, (3) dwarf stature, (4) productiveness, (5) freedom from suckers and branches, and (6) erect heads.

The drought resistance of the grain sorghums is very important. It is probably a combination of several characters, some actually drought resistant, as controlled transpiration and a strong root system, others only drought evasive, as earliness and dwarfness. Improvement in earliness is necessary in adapting the crop to regions having a short growing season.

It is in the western region previously described that the grain sorghums prove themselves most completely at home. They are here not only staple crops, but they are often the chief dependence of the new settler, because they may be grown as sod crops. By homesteaders with small means and limited equipment, they can be cheaply planted on breaking. They are often planted, cultivated, harvested, and even thrashed by hand under such circumstances.

When these crops were first introduced they were tried in various parts of the United States. One after another they were found unsuited to the conditions in most of the country and were discarded. But out on the Great Plains they grew in favor with the farmer because they were able to stand the prevailing conditions. They are able to grow and make profitable yields in hotter, drier climates than most crops. Some of them are early enough for use at comparatively high elevations. They are all cultivated crops, entering readily into the rotation with small grains. They furnish the feeding grain required on the farm, also some roughness, and occasionally both fuel and food in addition. The surplus can always be sold at fair to good prices. When grown on a large scale they are handled rapidly and profitably by machinery in every necessary operation from seeding to milling. They are undoubtedly suited to become the basis of a cattle-feeding industry that will make the Great Plains farmer prosperous.

Primarily these grains are and ought to be useful in feeding stock on the farms where they are grown. This fact accords with the history of these crops and is due to their adaptations for such use. They were the principal crops of the early settler in the dry-land areas of the southern Great Plains region. He not only needed a feeding grain but was often too far from market to sell it profitably if he had wished. The value of the grain for keeping work stock, growing animals, and dairy cows in excellent condition has long been recognized among the growers.

Durum or Macaroni Wheat.—This cereal is rapidly becoming one of the most important grain crops in the dry farming regions. It grows best in North and South Dakota, Nebraska, Kansas, Oklahoma and Texas. It can be cultivated in all the other parts of the West, but the quality of the grain is not so good. They must be grown in dry districts in order to produce the best quality of grain.

Macaroni wheats differ radically from the ordinary bread wheats, and in the field look more like barley than wheat. The heads are flat, compressed, and bearded, the beard often being black; the chaff is usually golden yellow, but sometimes black; and the grains are large, hard, yellowish white, and clear, or, in wheats of the best quality, sometimes translucent. There are also occasionally velvet chaff varieties. In Europe they are known simply as hard wheats, or durum wheats. The grain is much harder than that of the hardest bread wheats, and in the best varieties contains an unusual amount of nitrogen and a correspondingly small amount of starch. The quantity and quality of the gluten make them exceedingly valuable for making macaroni. They are extremely resistant to drought and resist the attacks of leaf rust and smuts to an unusual degree. On the other hand, they will not withstand hard winters, and are usually grown as spring wheats. This fact should not be a strong objection to them, however, for they will behave very differently from the ordinary spring wheats grown in Kansas and Nebraska. South of the thirty-fifth parallel they may be sown in late autumn.

Since the Department of Agriculture undertook the work the production of macaroni wheat in the Northwest has increased with astonishing rapidity. The estimated crop of the two Dakotas alone during the season of 1903 is 10,500,000 bushels. Perhaps no other new crop has been so warmly welcomed by farmers in the regions suitable to its growth. The reason for this is found in the splendid adaptability of these new wheats to the climatic and soil conditions of the Great Plains region. Macaroni wheat thrives in abundant sunshine, does not require a large amount of moisture, resists vigorously the attacks of the smuts and rusts, and is a strong grower, yielding largely (from 25 to 100 per cent) in excess of the ordinary bread wheats, which often produce indifferent crops in the semiarid regions of the Northwest.

The several varieties of macaroni wheat, while differing widely in their chemical and milling properties, nevertheless possess many traits in common. They have strong straws, which prevent lodging; also heavy and somewhat persistent chaff, furnished with long beards, which protect the kernels from the fierce heat of the sun and prevent shattering—a grave objection to our common blue-stems.

Methods of Cultivation.—The cultivation of these new wheat requires little variation from the methods employed in growing ordinary spring bread wheats. The same soils answer admirably; sowings are made at the same time in the spring, and the preparation of the soil is the same. It is probable that some varieties can be converted into winter wheats farther south. Owing to the large kernels of the macaroni wheats, and to the fact that they do not stool so freely, 5 pecks per acre are sown on good rich soil, while a poorer soil requires at least 6 pecks. Before harvesting, the grain is allowed to ripen fully, and if it can be thrashed without suffering from rains the qualtiy of the grain is much improved. It is better, therefore, to thrash directly from the shock, when possible. When the wheat is first stacked, before thrashing, it should be allowed to go through the usual sweating process and become thoroughly dry, otherwise it will offer some difficulty in thrashing. In any event, the thrasher must have a full set of concave teeth, and the seives must be so arranged that broken heads and white caps are faithfully returned to the cylinder for a second beating; otherwise much grain will be lost in the straw.

Classes of Macaroni Wheat.—It has been found convenient while investigating the different varieties of macaroni wheat to divide them into three classes: First, the Northern or Russian varieties; second, the Southern or Mediterranean; and, third, the miscellaneous varieties, which have come from more widely separated localities. In some respects all the durum wheats have properties in common. The kernels are somewhat larger than those of the common wheats, but as compared with one another a considerable variation in size and color is plainly observable. All the durums have an extremely hard kernel of a flinty or horny texture, sometimes appearing as if faintly translucent. In color the different varieties vary from a comparatively dark shade to a light yellow. But in regard to both hardness and color, the different varieties show marked variations among themselves. As a rule, the Russian sorts are harder and more nearly translucent. Both the Velvet Don and the Black Don have dark-colored kernels, while the Kubanka and the Gharnovkas have a lighter color. The Yellow Gharnovka is of a yellowish tinge, as its name indicates. The chaff and beards of most of the macaroni wheats are white, but in the Black Don both are black, while the Velvet Don has white chaff and black beards.

The Protein Content of Macaroni Wheat.—One of the first questions to arise in introducing the new wheat is, Can a variety or varieties of macaroni wheat be found that will preserve all essential characteristics in their new home? It must be remembered that it is a violent change of habitat to carry seed grown in the Azov districts of Russia half way round the globe and sow it at some point in the Great Plains extending from North Dakota to Texas. The peculiar property of macaroni wheat which makes it valuable for its distinctive uses is its protein or gluten content. If, then, these new wheats can be grown in the semiarid region for a series of years without suffering a diminution of protein, it is safe to infer that the transplantation may be successfully made.

A practical lesson should be drawn from the work already accomplished. Farmers should grow only the very best of these foreign wheats. The poor and medium ones offer no advantages. We are at the very beginning of a new industry, and it is important that we start right. Another warning also should be given at this stage: When pure seed of the best variety has been obtained the utmost care should be taken to keep it pure and free from bread wheats. Any admixture will lower the value of the products, and consequently lower the price of the grain.

Uses of Macaroni Wheat.—Macaroni wheat has many uses which will render it acceptable and valuable in American dietaries. In fact, it is deserving of a much more extended use than it enjoys at the present time; and no doubt when the manufactured products are to be had fresh and at a reasonable cost their consumption will increase enormously.

The first and most obvious use of macaroni wheat is in the manufacture of macaroni, vermicelli, and other forms of edible pastes. At the present time this country is importing these products largely. Three years ago not a single factory in the United States was making macaroni from macaroni wheat. All that was made in this country was of an inferior quality and was sold as such on the market, being produced from bread wheats. Now several factories are using American macaroni wheat, and some are proudly branding their products the best in the world, made in America from American-grown wheats, etc. It is safe to predict that in a short time all our factories will be using American macaroni wheat.

A second use for macaroni flour is for the purpose of blending. This high-grade flour mixed with a low-grade bread-wheat flour makes a most valuable article for bread making and pastry cooking. In southern Europe blended flour is largely used, and no doubt its use in the United States will increase as the supply becomes abundant and its value better understood.

A third use of macaroni flour is for bread making. Many tests have now been made by the Dakota stations and by private families, where the flour is accesible, in addition to the tests made by the Department of Agriculture. The testimony all points in one direction, namely, that bread made from macaroni flour is very palatable and nutritious. In fact, many prefer it to ordinary wheat bread. But the use of the flour extends to many other articles of common diet, such as rolls, bread sticks, griddle cakes, grits, etc.; and there is no reason why a breakfast food far excelling a majority of those in common use at present, in both palatability and nutritiveness, can not be prepared.

A fourth use for macaroni wheat and its products is in stock feeding. Owing to the fact that it is a surer crop than bread wheat, with a heavy yield, farmers will learn to turn to this abundant source of protein in compounding balanced rations. At times, when the price of bread wheat has been low enough to warrant, stock has been fed on it at a profit.

Determination of the Best Varieties.—Of course, as the cultivation of the wheat goes on there are many things to be learned. The necessary experience on the part of the miller and baker has already been referred to, but the farmer also will have to learn which are the best varieties of this wheat. It is known that about a dozen different kinds are now grown throughout the country, some of which differ from each other as much as the varieties of ordinary wheat differ, and it is already known that some of these varieties are considerably better than others, both in the quality of grain furnished and in the yield of the crop. For the Northwest, the bulk of the evidence up to date is in favor of the variety Kubanka. In the Southwest the Kubanka continues to be a very good kind, but two or three of the North African varieties are there among the best. Still other varieties are under experiment by the Department of Agriculture at a few points, and it has already been found that two or three of these varieties have certain unusually good qualities. It will require several years to determine thoroughly which are the few best varieties for the different portions of the semiarid districts where such wheat is adapted.

Dairying.—Dairying and poultry raising are the profitable lines to follow in dry land farming where the settler's capital is limited, as both give quick and regular cash incomes. The average annual rainfall on the Colorado Plains varies in different localities from 13 to 19 inches, adequate with good methods, to produce a profitable crop of wheat. In about half the years the rainfall is below these averages, and has dropped as low as 6.93 inches in 12 months, in one section, and in other places to as low as 7.11 to 10.74 inches.

In years of low rainfall, the moisture is not sufficient to produce crops of grain, but there is usually enough for fair yields of forage crops, such as milo maize, sorghum, kafir corn, corn fodder and hay from wheat, oats and barley. These forage crops are not marketable, but become money makers when fed to dairy cows and hens. Dairy cows and hens, properly selected and handled, will furnish a comfortable income and enable the farmer to pay cash for his family purchases, no matter how dry the year. Then, the dry land farmer should seed as much land to wheat as he is able to prepare thoroughly with intensive cultivation, and when he raises a crop, the money from it will be surplus cash and will not be needed to pay old store bills, as is the case with the strictly grain farmer.

When a good stand of alfalfa is well cared for it is very successful. It can be cut three or four times each year, and the annual yield of hay varies from 5 to 8 tons per acre. When successfully seeded in the fall of the year, from 2 to 5 tons of hay to the acre may be expected the following season. The productiveness of the soil will be built up more rapidly if the hay is fed to good dairy cows than if it is sold, for from 75 to 90 per cent of the fertilizing substance of the hay will be contained in the manure. While cows will not give the maximum amount of milk when fed alfalfa hay exclusively, this is usually a more profitable practice than to pay $25 to $30 a ton for grain and mill feed with which to balance the ration. The cows should be fed in stables and lots during the entire year, for the land is too valuable to be used for pasture. No cow should be kept that will not produce 600 gallons of milk yearly.

Unless a farmer has plenty of manure with which to enrich the soil, all of his land should be sown to alfalfa or clover just as soon as it is ready for seeding. No attempt should be made to grow other crops until the land has successfully grown alfalfa, clover, or some other humus-producing crop for one or more years or until stable manure can be obtained. When available, manure should be applied liberally and well incorporated into the soil. A light application on the surface of the ground is of little benefit except to keep the soil from drifting. Irrigation should be frequent enough to keep the soil moist, so that the manure will decay.

The Commercial Orchard.—To plant and care for an orchard until it is bearing profitably requires several years and much labor and money. For this reason, deciding the kind of fruit to be grown (whether apples, pears, peaches, apricots, or cherries) becomes a very important matter. Having decided the kind of fruit to be planted, the selection of varieties is likewise very important. This should be done with a great deal of care and study. The man with limited means can not afford to experiment with new varieties, however, superior they may be represented to be. Instead, he should plant the standard commercial varieties that have given the best satisfaction in the Columbia River Valley. Opinions have differed widely regarding this matter in the past, and the question is not fully settled at the present time. For this reason it is difficult to say just what should be planted, and the following recommendations are only made in the light of the best obtainable information.

Crops Grown.—Many varieties of wheat are grown in the dry farming sections, but the Turkey Red fall wheat has given the most general satisfaction. This wheat was imported into this country from Russia, is a very hardy growing variety, and the grain produces a flour of superior bread-making qualities. The straw is of medium size and strength.

Fall rye is a hardy grower and produces a large yield of straw. It is not considered a very satisfactory crop to grow. The Kubanka variety of macaroni wheat has shown itself to be one of the most satisfactory of the dry farm spring wheat.

Early maturing oats are more satisfactory on dry farms than are the later maturing varieties. The Sixty-Day and Canadian White, two rapid growing varieties, have shown good returns. The early maturing hulless and beardless varieties of barley seem well adapted to dry farm growth.

Flax appears especially well adapted to grow on new spring breaking. When the production of flax is to be carried on year after year the land ought to be plowed and then carefully cultivated.

Corn is a dry farm crop of great promise. At altitudes below 4,000 feet the seed may be matured while farther to the south three or four tons per acre may be grown almost anywhere. Select early ripening dent varieties.

Clovers are not generally successful on dry land. Ordinarily they require liberal water supply and do not thrive where the water is scarce. Alfalfa gives promise of becoming the best forage crop for the dry land farm.

Excellent crops of potatoes may be produced upon dry land and the quality is generally regarded far superior to that of irrigated potatoes.

Roots, such as mangels, sugar beets, and rutabagas, require a deep, mellow soil plowed the previous season. Sow in the moist earth one or two inches deep. Keep the surface stirred and level. Beans are a very promising dry land crop. They are light users of moisture, hardy, admit inter-tillage, and have a high market value. Garden vegetables are very successfully grown, provided the land has been well tilled the preceding season, and the earth mulch maintained by early and frequent cultivation.

Summary.—(1). That fall plowing is generally to be preferred to spring plowing.

(2). That while subsoiling has shown some indications of being beneficial it is not yet known whether the practice will be profitable and that plowing to a depth of 7 to 10 inches will probably give satisfactory results.

(3). That the three principal objects sought in the care of fallow land—moisture conservation, prevention or eradication of weeds, and preparation of seed bed—are best secured by shallow cultivation of sufficient frequency to maintain the surface of the soil in a fairly loose and well-pulverized state, and that the importance of cultivating at the proper time is paramount.

(4). That only clean and pure seed of the best variety for the locality should be planted.

(5). That all wheat seed should be treated with a formalin solution to prevent bunt, and that smut balls should be removed from the seed before treatment.

(6). That both very early and very late planting should be avoided, experience at the substation strongly favoring September 20 to October 20 as the best time to plant winter wheat.

(7). That spring grains should be planted as soon as possible after the surface soil has become dry enough to be worked without danger of excessive packing or puddling.

(8). That the most satisfactory rates for seeding so far determined are as follows: Wheat, 35 to 45 pounds per acre; winter barley and spring barley, 5 pecks per acre; winter oats, 6 pecks per acre; spring oats, 4 to 5 pecks per acre, the lower rate being favored for the drier localities.

(9). That the most desirable depth for planting wheat on a well-prepared seed bed is about 3 inches.

(10). That broadcasting should never be practiced in grain production; all grain should be drilled.

(11). That it is sometimes advisable to harrow fall-planted grain in the fall to break up the surface crust and that this is not often necessary except with early planted grain; that spring harrowing is frequently advisable, particularly on heavy clay soils, and that there is ordinarily no danger of injuring the plants by harrowing at any time before June 1.

(12). That the indications so far are against growing wheat continuously and in favor of at least alternate fallowing, where wheat is the only crop grown on a field.

(13). That the test of growing intertilled crops in place of alternate fallowing has given some results that indicate the practicability of substituting potatoes and, possibly, corn.

Authorities Consulted, and Extracts Taken from Many.—Y. B. 1903; Bu. Plt. Ind. Bs. 20, 59, 60, 61, 70, 187, 188, 203, 215; Div. Veg. Phys. Cir. 18; F. B. 294; Ariz. Univ. Bs. 27, 43, 48, 61; Colo. E. S. Bs. 14, 15, 17; Colo. Ag. Col. Bs. 123, 145; Univ. Idaho B. 62; Kans. Ag. Col. Bs. 18, 92, 93, 99, 100, 102; Mont. Ag. Col. Bs. 3, 61, 63, 83; N. Mex. Ag. Col. B. 61; Univ. Nebr. B. 78; S. Dak. E. S. B. 58; S. Dak. Ag. Col. Bs. 77, 82, 99; Tex. E. S. B. 115; 10th Ann. Rept. F. I. Utah; Wyo. Univ. Bs. 18, 80.

CO-OPERATION.

Co-operation among farmers has become a necessity to meet existing conditions. Without it they are in a measure at the mercy of others. Organization is the keynote of success. The most highly organized industries are those in which a large aggregate of capital is controlled by a small number of expert capitalists. Agriculture is, perhaps, the most extreme case existing where a very large aggregate of capital is divided among and controlled by a very great number of capitalists. Therefore agriculture is difficult to organize. For the same reason the ordinary industrial methods of organization have not been found easily suited to agriculture.

The homes and activities of agriculturists lie outside the great commercial world of cities. The necessary organization of the food supplies of the cities has resulted in the creation of a class who are enabled by means of organization to dictate prices, on the one hand to the urban consumer, and on the other to the rural producer. The countryman living on the farm does not always learn quickly of the rapid change taking place in the towns. To him it seems difficult to understand and control. As urban life became more complex and harder for the agriculturists to grasp, his position became more difficult. As the organization of the distribution of food among the urban population becomes more specialized and complex, the farmer finds himself coming into contact less and less with his old-time customer, the consumer.

The transportation of products has made necessary the assembling of those products at some point in their area of production. This has been done by the middleman. In this way he has rendered a great service to society, but it is a service that gave him the mastery. The control of the food supplies has so fallen into the hands of the middleman that it has inducted an unnecessary number of people into the business, and has made possible profits that are out of proportion to the importance of the service to society. Hence it is necessary for the farmers to act conjointly in their own interests.

There are two means by which co-operation may be organized: By means of a force from without such as the middleman; 2nd, from within by the farmer himself. All successful industrial organizations have come from within the industry. An organization of farmers must solve the following problems: It must break isolation of farmers by drawing them together under a common bond of interest; it must place the farmer as nearly as possible on the same financial base as his prosperous city brother; it must secure to him a fair share of the fruit of his toil; it must restore agriculture to its proper position which has been lost through bad business methods; it must replace bad methods with good business methods.—(B. 192 Ont. Ag. Dept.)

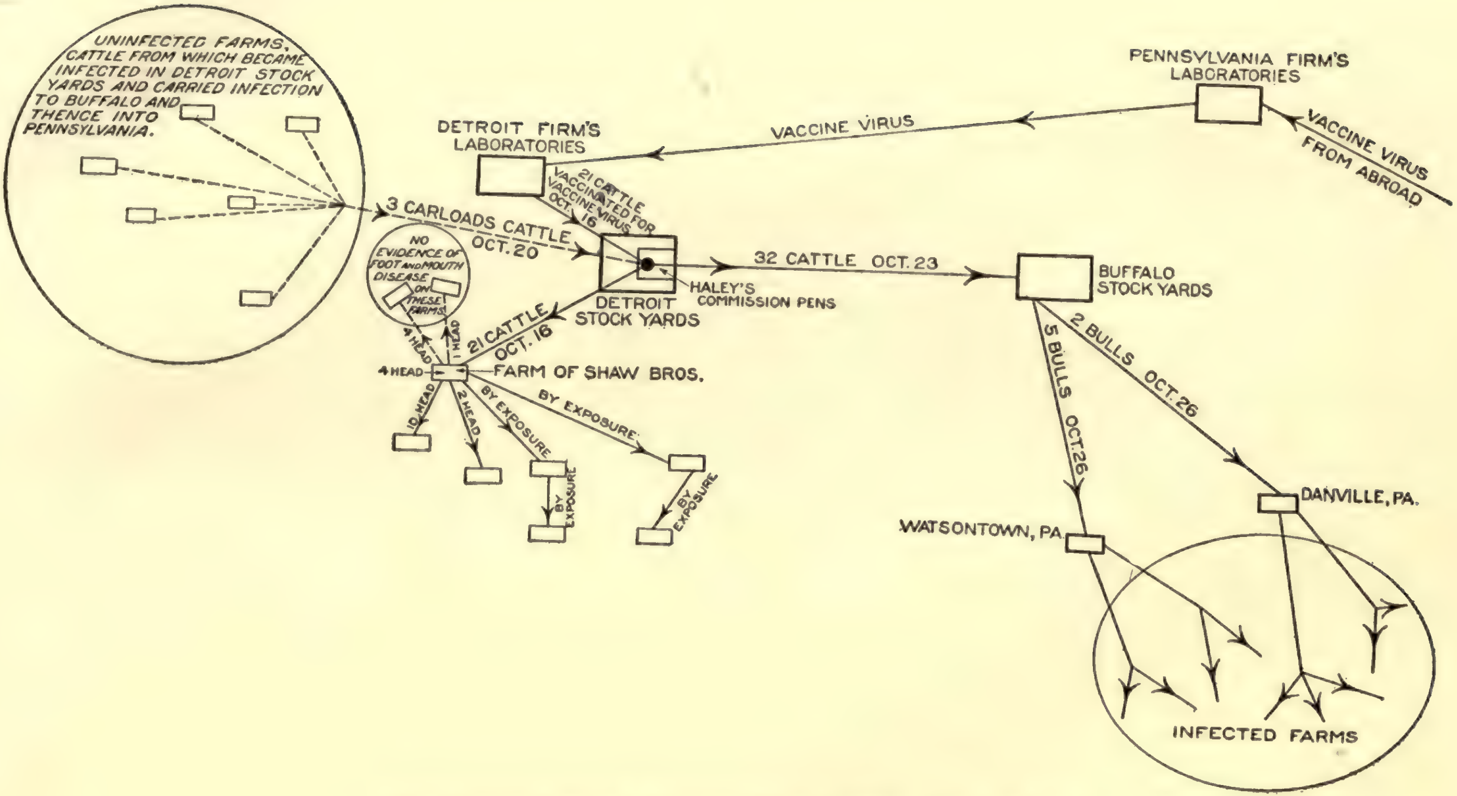
What is Co-operation?—It is an association for the purpose of joint trading, ordinarily among the weak and conducted always on an unselfish plan, on such terms that all who are prepared to assume the duties of membership may share in its benefits in proportion to the progress in which they may make use of their association. In the country this important field of activity is a solution to the problem of correct production and marketing. It is the farmer's solution to the problem of how to overcome isolation in business, difficulties of transportation, and other conditions that have long baffled him. The chief field of agricultural co-operation is that of marketing. If, for instance, it undertakes the manufacture of butter, it does so, or should do so, for the production of uniformity and excellence of quality as an aid in marketing. Wherever the object of marketing is lost sight of failure is sure to result.—(Ont. Dept. Ag. Bul. 192.)

Difficulties in Organizing.—All classes of farmers are constitutionally and proverbially distrustful of other people and of one another. In a fruit association there arise (such is the experience) the most inveterate jealousies. Each man thinks he is furnishing a better grade of fruit than his neighbor, though all share alike in the profits. Each one fears the other will reap some special advantage somehow. In particular, the appointment of managers, superintendents, supervisors of grading, shipping agents, and all other officials of the company offers a sufficient opportunity for the elaboration of all sorts of neighborhood quarrels. Each man thinks he ought to be manager, and when one man is finally chosen he is usually suspected of all sorts of favoritism. In any case, he is apt to be hampered in his business relations by committees, boards of directors, and various kinds of red-tape and foolishness. Often he has to consult a committee before taking any important action.

Another difficulty which arises from the same cause is that subscribers to such an association never want to pay a manager's wages. Two or three dollars a day is considered good pay. Yet such a man is compelled at times to handle thousands of dollars' worth of business. The position is such as in ordinary business life would command a salary of $5,000 a year or more. Where such conditions exist there is little chance of success. They may be avoided to a great extent if inexperienced shippers will limit the size of their organization until the minor details connected therewith have been thrashed out. A few selected growers are sufficient to demonstrate to the community the advantages of co-operation, and a healthy expansion will soon take place.—(F. B. 309.)

The problem of production seen from the farmer's view-point is one of marketing and the solution must be seen by the agriculturalists from a marketing point of view before he will improve his ways. Scientific investigation has done great things for production, but science finds itself continually check-mated by the refusal of the agriculturalists to adopt scientific methods. The fact is, farmers are seeking first to solve the great question of marketing before they take up the problem of scientific production.—(Ont. Dept. Ag. Bul. 192.)

Among the difficulties in organizing co-operative associations among farmers is to secure the proper amount of capital necessary to carry on the business of the association. Sometimes this capital is raised by loans from banks or private individuals; in other cases it is procured by the issue and sale of shares of stock as an ordinary joint stock company. Co-operation is a great economizer in buying for the use of the members of the Association. This form of co-operative activity seems to be successful in all countries. Among the things purchased by such co-operative associations are fertilizers,


UNINFECTED FARMS, CATTLE FROM WHICH BECAME INFECTED IN DETROIT STOCK YARDS AND CARRIED INFECTION TO BUFFALO AND THENCE INTO PENNSYLVANIA.
DETROIT FIRM'S LABORATORIES
VACCINE VIRUS
PENNSYLVANIA FIRM'S LABORATORIES
VACCINE VIRUS FROM ABROAD
21 CATTLE VACCINATED FOR VACCINE VIRUS OCT. 16
3 CARLOADS CATTLE OCT. 20
NO EVIDENCE OF FOOT AND MOUTH DISEASE ON THESE FARMS.
DETROIT STOCK YARDS
HALEY'S COMMISSION PENS
32 CATTLE OCT. 23
BUFFALO STOCK YARDS
21 CATTLE OCT. 16
4 HEAD
1 HEAD
4 HEAD
FARM OF SHAW BROS.
10 HEAD
2 HEAD
BY EXPOSURE
BY EXPOSURE
BY EXPOSURE
BY EXPOSURE
5 BULLS OCT. 26
2 BULLS OCT. 26
WATSONTOWN, PA.
DANVILLE, PA.
INFECTED FARMS

Map Showing Spread of Foot-and-Mouth Disease. Dept. of Agr.

machinery, supplies of all kinds for the farm and home, feeding stuffs, seeds, and creamery supplies. Large or small farms can cooperate for supply. It enables them to buy, in many cases, direct from the manufacturer, thus saving the profits of the middle man. Buying in large quantities they can secure lower prices, and also are able to get a better quality, especially is this true in the purchase of seeds and fertilizers. The benefits to be derived from such organizations are many. Small producers can make combined shipments in car lots, which is now considered the economic unit of shipment. Organizations, through the volume of their business, can secure minimum transportation rates. They can afford to maintain daily telegraphic communications with all of the important markets and are thereby enabled to divert cars already en route to places where the demand is greatest. Growers are advised when to hold and when to ship. Uniform grades and packs are secured. Organizations are in a position to know the actual supply of their respective communities; hence managers, working in harmony, can regulate prices to a considerable extent. Through the association the members can procure packing material, fruit-picking baskets, spraying materials, and pumps, potato bags, etc., at a greatly reduced cost. Successful associations require choice products. By an interchange of ideas and experience members are in position to eliminate unprofitable varieties of fruits or vegetables from the community and to develop thorough and economic systems of cultivation. These and many other advantages might be noted.—(F. B. 309.) Co-operation also materially assists in production. It stimulates production, yet by the Association watching the results it tends to prevent in a large measure over-production.

Benefits.—It gathers together the products from the numerous farms, classifies and grades them. It takes these products and places them on the market as the produce from one Association or Federation of Associations of which the farmer is a member. It retains the interest and control of the farmer in his products until they reach the consuming market. It thus creates a community of interest. It attracts particularly to the interest of the farming community a class of men who act as the farmer's middle man, who are the managers and sales agents of the Association. These middle men are responsible to the farmer and are hired and paid by him to work for the farmer's interest. It relieves the producer in a great degree of the business of marketing thus leaving him free to give more careful attention to those things for which, by nature and training, he is better fitted. It also educates him in the field of science and improvement in production. By means of all these, it will greatly increase his profits.

In the handling of dairy products it gives him an opportunity to secure profit from the use of the by-products, which are a total loss to him when acting in an individual capacity. In fruits and vegetables it secures for him the chances of cold-storage that would not be possible on the homestead. It also gives to him all the benefits that may be secured in the way of transportation.—(Y. B. 1900; Ont. Agr. Dept. B. 192; F. B. 309.)

Results.—In the fruit growing sections of the Pacific slope co-operation in production and in marketing has passed the experimental stage. As an example of the good effects that may be secured by this co-operation, the Grand Junction Fruit Growers' Association of California, in ten years increased the number of cars of fruit shipped from 167 to 1,036; the total amount paid growers from $54,085 to $555,813, and the volume of business from $88,937 to $814,278.—(F. B. 309.) Car lot shipments are always much more economical than in less than car lots, and by the operation of the Association in collecting together large quantities of any farm product, very much can be saved in shipping by the car-load and in the proper care and handling of the shipment.

Method of Organization.—The details of organizing will vary more or less in their solution, depending greatly on the nature of the region, and the crops to be handled, and the volume of business to be conducted. First of all should be careful study of the co-operative movement and getting the idea. Learn the ethics and science of the movement; having learned that co-operation seeks for the highest moral qualities and best business acumen of its members, teach these principles in season. Get the advice of the best co-operative leaders. Conditions, however, that make for success in one section may not exist in another. Many of the societies that have been organized are very faulty in construction, but this is not recognized by the manager or officers. In many cases the personality of some individual in the society makes it a success. When he drops out trouble will come because of faulty organization. The personality of certain men, however, is a great aid to success. Get the leaders in your section interested and half the battle is won.—(F. B. 309; Ont. Dep. Ag. B. 192.) Study the business possibilities of your section and every branch of farming thoroughly. Begin by organizing the branch that seems to offer the greatest likelihood of success. Do not fear to wait for results, people must learn slowly either by education or experience.—(Ont. Dept. Ag. Bul. 192.)

Causes of Failure.—Among the causes of failures may be classed: Unreasonable and cranky members; starting on too large a scale; allowing expenses to run higher than the business guaranteed; poor systems of book-keeping; bad by-laws and bad management; dishonesty; no attention paid to the training of men.—(Ont. Ag. Col. Rep.)

Co-operation aims to regulate the returns of the middle man and to hire him to do the farmers' business. In order that a manager shall do his best he must be able to give a great deal of his time to the affairs of the society, this means he must be paid a fair return. The idea of working together is not thoroughly understood, nor the moral qualities of understanding and mutual helpfulness appreciated in business. Private business is intensely selfish. This is the common cause of the failure of societies among the farmers. Some individuals want more than others, and are not willing to assume their full share of the responsibility of the society.—(Ont. Ag. Dept., B. 192.)

Moral Effects.—Experience has demonstrated that in the aspect of morals such associations have been important. Members should be selected on the basis of morality, business acumen and citizenship and not on that of favoritism or wealth. The effect of this system of selection is said to be very marked and does more to raise moral standards and teach citizenship, than any other force which has ever been introduced into rural society. Members are educated in democratic government and taught to accept their proper share of responsibility, by the exercise of the duties which each member owes to his society. The idle man becomes industrious, the spend-thrift becomes thrifty; the drunkard reforms his ways and becomes sober; the tavern-hunter forsakes the inn; the illiterate, though a grandfather, learns to read and write.—(Ont. Dept. Ag. Bul. 192.)

TENANT FARMING.

Disappointments in tenant farming arise because of the too frequent lack of an equitable adjustment of the returns of the farm between the owner and the tenant; the lack of well-laid plans for keeping up the yields and the productiveness of the farm through the years; and short-term leases, which keep the tenant in an unsettled frame of mind as to the permanency of his tenure and lead him to endeavor to get as much out of the land each year as possible, with little or no attempt at soil improvement or wise farm management, thus contributing to the deterioration of the farm.

Why Tenant Farms Deteriorate.—In tenant farming there are two main reasons why farms usually deteriorate: (1) The owner desires as large a share as possible of the profits of the farm and frequently hesitates to put any large portion of the profits back on the farm in the way of permanent improvements or in keeping up the place, and (2) the tenant regards the farm primarily as a means of acquiring enough money to buy one of his own, and conducts the rented farm along the line of the greatest immediate financial returns to himself. It is the farm that suffers in each case. The generally decreasing returns soon bring discontent both to owner and tenant, and frequent changes of tenant follow.

A proper and equitable adjustment between owner and tenant is not easily made, but is the end to be sought. It would insure more permanent tenancy. It would relieve the owner of the duties of management and the tenant of the burden of acquiring large capital before he goes into business for himself.

Advantages and Disadvantages of Tenant Farming.—Speaking generally, tenant farming is not a type to be encouraged in North America. Small farms tilled by their owners are regarded as the ideal, because such farms tend to build up a conservative, home-loving people. There is a place for tenant farming in American agriculture. If a young man desires to go into farming in these days, he requires considerable capital. It takes a long time, working out by the day or month, to acquire that capital, and good land is expensive. If he wishes to buy a farm, it usually takes all the money and credit at his command to buy the land alone.

The acquisition of the land is only the beginning of the struggle. Investigations have shown that in farming only about half the capital required is invested in the land. The remainder is invested in buildings, fences, farm machinery, tools, and live stock, sufficient cash being kept on hand for running expenses. Many a man buying a farm will put all his money into the land and then struggle the remainder of his life with insufficient working capital, trying to meet expenses and make the farm earn its equipment. Should the same man let some one else furnish the farm and put his own money into the working and proper handling of it he would require much less capital. He would be relieved of a large burden of debt, and with adequate equipment and cash on hand the farm would be run far more efficiently and, generally, to his greater profit.

A man who has acquired some money, as a laborer or otherwise, who desires to be independent but who has not sufficient money or credit to buy and efficiently equip a complete farm, may let some one else furnish the farm while he furnishes the labor and part or all of the equipment and other working capital. Whether the results of such an arrangement are mutually satisfactory depends upon several factors, which may be profitably considered more in detail.

Fundamental Principles of Tenant Farming.—1. A cropping and fertilizing system which will return satisfactory yields of each crop yearly and still maintain permanently the productiveness of the farm throughout future years must be provided. The owner should make the plan.

2. Terms of agreement as to rental must be fair to both owner and tenant. If advantage is taken by either owner or tenant of a lack of knowledge in the other of what is a fair adjustment of the returns from the farm, the results are bound to be unsatisfactory and the relationship brief.

3. The terms of the lease should be such as to lead to permanent tenancy. A tenant can not and will not do his best by the farm if he is to remain on it for only a short period.

On a large estate in Maryland which is leased to tenants the following system has proved satisfactory to both tenant and owner:

The agreement is drawn up for one year. If the contract proves mutually satisfactory it is continued in force during succeeding years without further attention. The owner furnishes the farm and buildings; furnishes paint for painting and lime for whitewashing buildings and fences; pays for all permanent improvements, such as the clearing of new lands or the tile draining of old lands; furnishes material for fencing; furnishes half of the fertilizer and half the seed wheat, seed oats, and seed corn, and pays the taxes on the real estate.

The tenant furnishes all tools and labor for working the place and all stock kept on the place. He also furnishes half of the fertilizer and half of the seed wheat, seed corn, and seed oats; furnishes all the clover and grass seed used, which by the terms of agreement is 8 pounds of pure clover seed per acre (though 1 to 2 quarts of timothy seed may be added); hauls material and builds fences free of expense to the estate, and applies the whitewash and paint furnished by the estate.

While the owner supplies all the buildings necessary for a general farm, he does not provide buildings which would be of use primarily for the tenant. Thus, if the tenant wanted to engage especially in dairying, the owner would derive no direct financial benefit from the industry and hence the tenant would have to put up, out of his own resources, such extra buildings as he might need.

In the division of returns the owner gets half of all the wheat, oats, and corn grown on the place, delivered free by the tenant at the elevator or nearest market. The tenant gets the remaining half of the oats, wheat, and corn, and in addition he has all of the hay and pasture, all the cornstalks, and all the straw for his stock. In case, however, any hay, straw, or stover is sold off the place the owner gets half the proceeds. In addition to this, the tenant is permitted to pasture a small flock of sheep on the wheat fields when the ground is frozen, from December to the last of March. This is of no advantage to the owner, but is of distinct advantage to the tenant.

It is a wise landowner who looks beyond a particular year to the future welfare and productiveness of the farm and makes terms with the tenant which tend to return to the soil each year a reasonable proportion of the plant food and humus removed and at the same time allows the tenant as large a measure of independence as possible. The simple provision requiring the tenant to pay the landlord half of all the money received for roughage sold off the farm, but require nothing if the roughage is fed to stock or left on the place, leaves the matter open to the discretion of the tenant, but inevitably tends, nevertheless, to the maintenance of a large number of stock on the place and the consequent production of a large supply of manure for the continued renewal of the productiveness of the soil.

It is now seen why the five-field system is a little more in favor with the tenant than the four-field system, since it gives him more pasture and hay, all of which he may have for feeding to stock. In this the tenant gets both the food value and the manurial value of the forage grown, while the owner gets only half of the increased grain yields obtained as a result of applying the manure produced by feeding this roughage on the place.

Live-Stock Management.—In a system of farming such as is practiced on these farms, where the tenants are generally free to follow their own course in all matters except as to the cropping system, there is bound to be a wide variation in the management of live stock. Some of the tenants are inclined toward dairying, others toward the keeping of beef cattle, some toward the maintenance of as much stock as possible, even to the extent of purchasing considerable feed, while others keep as little stock as they think will economically consume the roughage raised.

On one of the farms, consisting of about 275 acres, which seemed to be typical of the average, there were kept about 9 head of work stock, 12 milk cows and their calves, 50 sheep, and 100 hens. While it is generally conceded that hogs would be a good paying investment if they could be kept free from cholera, very few were found on any of these farms, owing to the prevalence of this disease in that section of the country. Scarcely enough hogs are raised to supply the farm with meat.

The work horses and mules are kept up and fed practically the year round. They are fed principally corn, corn stover, and hay. The cows are allowed to run on clover pasture from about May 1 to October 1 and are not fed unless pasture becomes very short in August and September, in which case they may be fed green fodder. From October 1 to December 15 they run on pasture, but are fed fodder and corn, and from December 15 to May 1 they are kept in the barn and barnyard and fed corn stover, wheat straw, corn, and possibly some ground grain other than corn.

The grade sheep are pastured on the green, growing wheat in suitable weather from December to March, when they are turned into the clover field to stay until October 1 or November 1, after which date they are kept in the barn and barnyard and fed principally straw, stover, and corn. The ewes are bred to lamb in January and February. The lambs run with the ewes until some time in May or June, when they are sold at weights of 40 to 50 pounds each at a price averaging about $5.50.

Under the system of management described, this stock consumes about all the grain and forage of the farm available for the use of the tenant. A greater number of stock would make the purchase of feed necessary and a smaller number would leave a surplus of forage to be sold.

Returns to Tenant and Owner.—The tenants on the farms of this estate are apparently as prosperous as the average farmer of the country who owns his farm. They live in commodious, substantial, and well-furnished houses, with well-kept and neat-appearing surroundings. They give their children up-to-date educational advantages. They apparently have plenty of leisure and carry on their farm work largely by means of hired labor. As an illustration of their prosperity, one of them on a farm with 250 acres in cultivation, employing 3 men 10 months in the year and keeping 10 work horses, stated that during the last 11 years as a tenant he had out of his profits bought and paid for a farm costing $7,200 and had laid up about $600 besides. Meantime he has lived well, is educating his children in the city schools, and has done considerable traveling over the country. Another tenant on a farm of about the same size stated that his income from the sales of stock he was able to keep, by means of his pasture and roughage, was sufficient to pay the running expenses of the farm.

Possible Improvement of the System.—The system of farming on the estate under consideration was developed by a business man who had to devise methods of management that would seldom require his presence on the farm. This necessarily meant the same or a similar scheme of administration on all the farms. Every farm in the estate is, therefore, run on practically the same plan, regardless of varying soil conditions and the adaptability of the different tenants to such a type of farming. This was the easiest and perhaps the most economical method of handling so large an estate. Nevertheless, it is undoubtedly true that could each farm be operated with reference to the best development of that farm alone, considerably higher yields could be obtained. Strictly high-grade farming should make these farms yield on an average at least 50 bushels of corn and 25 bushels of wheat to the acre. A method of handling that would produce these results, however, implies constant supervision by a thoroughly trained manager, well versed in both the science and practice of agriculture. The very thin stands of clover observed on some farms and the actual results secured on a few farms indicate that in many instances lime or some other soil improver is needed for the best development of the clover crop. It is believed by many farmers in the section of country where these farms are located that lime should be applied at regular intervals.

On some of the farms of the estate having sandy loam soils it is probable that an increase in the potash supplied in the fertilizer would prove beneficial. A skilled manager would also introduce better cultureal methods on some of these farms and bring in improved strains of corn and wheat. However, for a scheme of management that relieves the owner of the responsibility of details it would be difficult to devise a better plan than the one already adopted and in operation.

Distinctive Features of the System.—The distinctive features of the tenant system described in the foregoing pages follow:

1. The tenant is well provided with a comfortable house and with barns and other outbuildings.
2. He is encouraged to keep live stock and is supplied with equipment for fencing and shelter.
3. He is given all the roughage when he feeds it, but only half when he sells it, thus making it to his interest to feed stock and return the manure to the land.
4. He is under contract to use on certain crops fixed quantities of fertilizers of a specified formula; the quality of this fertilizer is guaranteed by the estate.
5. He must sow a given quantity of clover seed each year. This is to his advantage, as he gets the crop either for pasture or for hay, and in addition he receives the benefit of it as a soil renovator. To their own disadvantage, many farm owners neglect to sow clover when the price of seed is high or for other reasons. Under this tenant system such neglect is made impossible without violating the contract. Herein is one advantage this system may have over systems usually followed by owners.
6. He takes an interest in the farm on account of his belief in the fairness of the contract and in the permanency of his tenure.

Systems for Tenant Farms.—1. A good system, with reference both to rotation and the maintenance of soil fertility, is essential to a permanently profitable farm.

2. Tenant farms are especially liable to decrease in productiveness as the years go by because of the general lack of an adequate system for maintaining their soil fertility.

3. Plans for farming are possible whereby both tenant and owner can make a fair profit and the farm still be kept permanently productive.

4. The owner should make the plan, since he is the one most vitally interested in the continued productiveness of the farm.

5. The plan should be based on: (*a*) A rotation of crops which of itself will keep up the humus and nitrogen supply of the soil over the whole farm; (*b*) a manuring or fertilizing system which will keep the soil adequately supplied with phosphorus, potash, and lime; (*c*) a division of the expenses and the returns of the farm which shall be fair to both owner and tenant; (*d*) terms of rental which shall induce permanent tenure; and (*e*) a simple system easily understood and easily carried out, based on crops and practices best adapted to the locality.—(F. B. 437.)

DRAINAGE.*

Farmers frequently desire an improvement in the general management of their lands without realizing the exact changes that will be necessary to bring it about. When they find their land too wet for cultivation, they put off the active steps to remedy the evil.

Facts which are easily discerned by the casual observer have pressed the subject of drainage home to both practical farmers and nonresident landowners in a most emphatic way. Those who have gone further into the subject of soil improvement by drainage have discovered greater advantages and more surprising benefits than were formerly thought possible. It is conceded to be a necessary accompaniment of scientific agriculture, and our most progressive farmers have taken advantage of it to a greater extent than is generally supposed. It is an improvement applicable to all land not possessing natural drainage, and hence is required for the attainment of the best results from some of our most fertile land. The farmer, when convinced that it will be to his interest to construct some kind of a drainage system for the improvement of his soil, desires to know how to plan and perform the work in an effective way at an expense not exceeding the limit of profitable returns which can reasonably be expected. He will find it an advantage to have an intelligent idea of the theory as well as of the practice of drainage in order that he may adapt his work to the several varieties of soil and conditions with which he has to deal.—(F. B. 187.)

A drained soil is one which is moist but not saturated with water. Soils for the production of the plants most prized by the farmer, gardener, and fruit-grower, must, in addition to other necessary elements, contain a definite percentage of water in order to yield the largest returns. If the soil contain too little moisture the plants are dwarfed, or the crop yield curtailed; if too much water it is practically worthless for cereals and other valuable crops. Plants take their nutriment from the soil in liquid form only, it having been prepared by natural chemical action of heat and moisture on the elements in the soil. An excess of moisture reduces the temperature, excludes the air and dilutes the plant food, thus retarding or entirely stopping the growth of the plant as effectually as a lack of moisture. The soil that contains the proper percentage of moisture is commonly called dry soil to distinguish it from those containing an excess of water, which are called wet soils. A perfectly dry soil is dead, and is worthless for producing crops. A soil that contains an excess of water can be rendered fit for high cultivation by proper drainage.

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* For illustrations, see pages 105, 123, 231, 308.

Drainage problems may be divided into two classes: Those involving individual drains, running through well defined courses, and those involving a level area requiring systematic drainage, that is a drain every few rods. The individual drain is a comparatively easy proposition, yet many failures result. These failures may be due to having the fall the wrong way, or in having too steep a grade. These mistakes occur from use of wrong methods. Too much care can not be taken in constructing the ditch or laying the tile.—(F. B. 187; Ont. Ag. Dept. Bul. 175.)

Methods.—Two methods of drainage are in use: By open ditches and by under-ground tiles. Surface drainage, as commonly understood, is accomplished by open ditches, which, in addition to receiving and removing water from the surface of the contiguous land, may, if sufficiently deep, act as receiving drains for water which percolates through a porous substratum, and under such conditions facilitates underdrainage. Removing water downward through the soil instead of over the surface is of great advantage to the soil. Percolating water carries into the soil all plant food; it dissolves and prepares the crude soil; the frost goes out earlier in the spring, so that planting season opens one or two weeks earlier than when soil has surface drainage only; the effects of drouth are diminished. When it is desired to reclaim and improve large areas of level land, such tracts must be cut up into sections or districts by large open ditches in order that tile-drains may be laid in every part without necessitating the use of mains too large and costly to be profitable. While these open ditches are not desirable in themselves, since the land they occupy can not be used for any other purpose, and though they often divide the land into tracts of inconvenient shape, yet they are necessary to every system of underdrainage. They should be located with care, following the course of natural drainage as nearly as maybe, with due regard to straight courses.—(F. B. 187; Ark. Ex. Sta. Bul. 104; Ont. Dept. Ag. Bul. 175.)

Benefits of Drainage.—The profit derived from draining wet land is more apparent when we consider that the same labor that is bestowed upon undrained land will produce from 20 to 50 per cent. greater yield of cereals where the land is drained. As a rule, lands to be drained should have a large supply of fertility, drainage being the only thing needed to make them productive. It has, however, been found by experience that soils which require artificial fertilizing frequently become very productive when drained, since the fertilizers applied are able, through the effect of drainage upon the soil, to bring into use natural resources hitherto hidden and unavailable. The question should be looked at in the following way: If the farmer own the land he must pay the taxes, keep up the improvements, and procure the necessary help and implements for cultivating it. If there is land which he cultivates at a disadvantage, because it is too wet to yield a full crop, or possibly yields none at all, proper drainage will cause this land to yield a full crop without the expenditure of any additional labor, seed, or capital, and the entire increase may properly be regarded as the profit of drainage.—(F. B. 187.)

Construction of Open Drains.—Ditches upon rolling land may differ from those on level land in several important particulars. Those for the former, having a grade which gives a rapid flow, may be comparatively small and shallow. The outlets for tile-drains may, if necessary, discharge at shallow depths, since the lateral slope of the land is such that the drains may be laid at the desired depth only a short distance from their outlets. They may have narrow bottoms, since the velocity of flow is sufficient to scour and deepen them. In level land, however, it is often necessary to provide for practically the entire drainage, with but little assistance from the natural slope of the land. The depth of ditches with grades of from 1 to 4 feet per mile should ordinarily be not less than 6 feet and the bottom width not less than 4 feet. The side slopes in loam or clay soils may be made at an angle of 45°, or what is called a slope of 1 to 1. Where the soil is loose and sandy, the slope should be 2 feet horizontal to 1 foot vertical, called a slope of 2 to 1. Ditches excavated with teams and scrapers can not be profitably made with slopes less than 2 to 1.

The well-known method of making ditches with a plow and scoop scraper need not be described. Where the earth is sufficiently dry to afford a footing for teams and for the operation of the plow and scraper, it is an economical method of making ditches. A large part of open-ditch work must be done when the ground is wet and in swamps under conditions where it is impossible to use teams. It is also necessary at times to make deep excavations, where water is sure to be encountered and where the earth is of such a character that it can not be handled by teams and scrapers.

There are machines which have been tried and found adapted to the work where the ordinary scraper can not be employed. For the making of small and shallow ditches what is known as the capstan ditch plow is used in some localities. It is an immense plow, which makes a ditch by cutting and throwing the earth from the center each way, its action being similar to that of a common sod plow. There are wings which push the earth thrown up 3 feet away from the edge of the ditch, leaving it in a large, continuous ridge on each side. The plow is pulled by two capstans, each of which is turned by a team of horses.

Underdrainage.—The history of drainage shows that a great variety of methods and materials have been employed in the work, many of them very effective and all of them proving the value of drainage in agriculture. Well burned clay pipes of circular form and one or two feet long are laid in a continuous line through the soil upon such a grade that the water in them will be carried by gravity to some lower point. The water enters the pipes through openings left between the ends or joints. The ends of the tiles should be placed together in order to prevent the soil from entering, yet not so close as to prevent the entrance of water.

The drain being surrounded with soil, the spaces of which are filled with water, the water percolating the soil enters the pipes through the crevices and is carried off. Other water of the soil takes the place of that removed, the water of saturation gradually passing from the surface downward, the soil near the level of the drain being the last to be relieved. This process does not leave the soil without moisture, but only removes the surplus. It does not remove water from below the level of the drain.—(F. B. 187; N. H. C. B. 118; Ark. Ex. Sta. B. 104.)

Kinds of Tile.—The tiles used should be round in form, straight and well burned. They need not be vitrified in order to be lasting, but every particle should be completely burned, no matter what kind of clay is used. Such tile is then almost indestructible in earth and water. When exposed to long continued freezing and thawing at the outfalls, the best vitrified pipe should then be used. After one has become familiar with the ware of a particular factory, properly burned tiles may be readily distinguished by their color, and by their ring when struck with a piece of steel. Good clay may usually be semi-vitrified if skill be used in burning. Porosity of the finished ware is not important, as all water enters the joints. Vitrification, though not essential, is always a desirable quality in drain tiles.—(F. B. 178; N. H. C. B. 118.)

Size of Tile and Fall of Drains.—The size of the main drain will depend upon its fall and the area which it drains. The greater the fall the smaller may be the tile. If the fall is doubled the carrying capacity is increased about one third. A four-inch main will suffice for most ordinary systems where not more than ten or twelve acres are to be drained. If twenty or thirty acres are to be drained into one main it should be five or six inches in diameter. Tile larger than necessary should not be used, as the cost increases much faster proportionally than the size of the tile; for example: Three-inch tile may be listed at $25, four-inch at $45, five-inch at $75 and six-inch at $100 per thousand.

For laterals a three-inch tile will usually be found most satisfactory, as it is large enough to carry off in a reasonable time all the surplus water of our heaviest rains. The danger in using smaller tile lies in the fact that it does not take a great deal of sediment to fill them, and unless they are laid on a perfectly true grade with a good fall their efficiency will soon be diminished. A variation of an inch below a true grade will result in filling a two-inch tile just half full of sediment, while an inch of sediment in a three-inch tile will only reduce its carrying capacity about one-fourth. It is pretty difficult to determine the proper size of tile unless the detailed conditions under which they are to be laid are known. Errors resulting from too small tile are most serious in their effects and the only safe plan is to be sure they are large enough even though the first cost is somewhat greater.

In regard to the fall of drains, it may be said that the best rule is to have ail the fall possible. A foot to the hundred feet is desirable if it can be had. Cases will sometimes occur where three inches or even less must be accepted and in these instances the bottom of the ditch must be carefully leveled and graded so that no sags will occur. It is important, also, to have a uniform fall, that is, not to change from one grade to another in the same line of tile. In changing from a steep to a less steep grade the velocity of the water is checked and there is danger of sediment being deposited where the change is made. Of course there is no objection to changing from a small grade to a greater one for in this case the velocity will be increased and the sediment will be the better carried onward.—(N. H. C. B. 118.)

Depth.—Depth of drains is also a variable distance depending largely upon soil characteristics. In some cases drains have been laid four feet deep with indifferent results, while drains of two and one-half feet deep on the same land have been successful. Four feet is considered deep drainage, three feet medium and two and a half feet shallow drainage. In general three feet is a safe depth, but on some soils containing very thick and close hardpans it is safer to lay the tile at two and a half feet, if such a depth will keep them above this impervious subsoil. Drains should be placed as deep as they will receive the water readily, with four feet the limit in clay and alluvial soils.

Aeration.—Aeration of the soil is one office of the underdrain, and is of great benefit to very close soils. In treating such soils it has been found beneficial to provide surface vents to the drains for the purpose of inducing a more rapid circulation of air through the drains and soil. In this way some refractory soils have been drained and greatly improved in texture. Shallow drains in such cases serve the purpose better than deep ones.—(F. B. 187; Ark. Ex. Sta. B. 104.)

Distance Apart.—This depends chiefly upon the nature of the soil and the depth of the drains. Drains should be sufficiently close together to remove the surplus water and lower the water midway between them. Water flows much more freely through coarse, sandy and loamy soils than through close clays, hence the more open the soil and subsoil the farther apart can the drains be placed.

To secure efficient drainage the individual lines should be placed sufficiently near to each other for the effect of one line to reach that of another on either side so as to bring all the soil within the active range of the drains. The distance apart will depend upon the closeness of the soil, or, in other words, upon its retentive character. Soils are spoken of as open or close with respect to their drainage properties, all variations in each class being recognized and requiring drainage treatment according to their several characteristics. It follows that in practice drains are placed from 30 to 300 feet apart and from 1½ to 4½ feet deep. These various conditions can not be described in sufficient detail to give a clear understanding of the requirements of each soil. In case of doubt regarding the proper distance apart for drains, they may be so placed that in case more perfect drainage is required a line may be laid midway between the lines. In general, close soils which consist largely of clay should have drains from 40 to 75 feet apart, and open soils from 80 to 300 feet apart. In the first instance, which is the more frequent system, tiles 2½ to 3½ inches in diameter may be used for laterals, and for the greater distance those 3½ to 5 inches in diameter should be used. It may also be said that one line of 5-inch or 6-inch tile may sometimes be used in such a way as to afford good drainage to an entire field.—(F. B. 187; Ark. Ex. Sta. B. 104.)

Location.—One of the most important considerations in a system of drainage is the location, especially as regards the outlet. A field, of, in fact, an entire farm, may sometimes be thoroughly drained by simply laying large tiles in those parts which are uniformly too wet for profitable cultivation. This is on the theory that the other parts have sufficient natural drainage. In such cases main lines should be located in the course of natural surface flow, with due regard also to straight courses. Branch lines should follow the same general law. This does not mean that the curves and crooks which are always found in natural depressions should be followed. Land which requires drainage always lies in natural areas of greater or less size, each having one point to which all drainage must finally come. These general areas are again divided into subareas each having its outlet within the limits of the general area. The boundaries of these areas should first be determined and the plans so made that when the drainage is completed the entire tract is provided for. A failure to do this is a fruitful source of disappointment to the farmer. The outlets should always be at the lowest available point, so as to secure the greatest amount of fall. Just as few outlets should be had as possible, as they are frequently a source of trouble.

Next locate the main, having it follow the line and direction of the lowest lying ground. This can be done by noticing the channel in which the greatest amount of surface water tends to run after a heavy rain. The main will thus be likely to have a location somewhere near the center of the area drained rather than on one side of it. Of course, when this is done, the laterals entering from both sides drain a certain amount of ground already drained by the main, but as the main in this case is supposed to be in the lowest ground most needing drainage, the extra amount does no harm. On a comparatively flat piece of ground, where there are no particular low-lying channels, it is better to locate the main at one end or side and place the laterals in parallel lines at nearly right angles to it.—(F. B. 187; N. H. C. B. 118.)

Efficiency of Tiling.—Again it should be emphasized that while plants require a moist soil, they cannot grow in a wet one. The tile removes the surplus water. Plain roots need food from the air just as do the parts above ground. When nearly all the spaces in the soil are filled with water, very little air can exist there. Drainage helps to ventilate the soil; the tiles form passage-ways through which the air is forced by atmospheric changes. Drainage increases the room which the roots may occupy. It also makes the soil warmer. This hastens the germination of seed and lengthens the growing season. A very important effect of drainage, a singular one in fact, is to increase the effective soil moisture. From the higher temperature, coupled with the presence of more fresh air, the drained soil is superior in another way. Soil is alive with bacteria. The little organisms are to the plant what the cook is to the family—they prepare the food, make it edible to the plant, so to speak. By their agency manure and clay and sand, which the plant cannot use as such, are changed into salts, which dissolve in water, and with it pass into the roots to sustain the plant. These bacteria need fresh air as much as plants or animals do. In the drained land there is plenty of it. Moreover, a congenial temperature is needful as much to them as to man, and this, too, they find in the drained soil. Here, then, they thrive.—(N. H. C. B. 118; Ont. Ag. Dept. B. 174.)

Cooperation.—When the outlet ditches are located on land belonging to one individual, he has merely to construct them as he chooses and pay the cost of the work. But in all large tracts in which a number of landowners have interests, open ditches must be constructed by the cooperation of all parties benefited. In several States methods of doing this are provided for by statute. Outlets for the drainage of tracts varying from a few hundred up to many thousand acres have been provided for in this way, each owner within the district paying a share of the expense of such work proportionate to the benefit he derives. It is intended that when these main channels have been made, each owner shall be provided with an outlet for his drainage and that all subsequent drainage of his own land shall be done at his own expense, without in any way infringing upon the rights of others, while the general outlet will be controlled by the proper officers as provided by law.

It is not often that drainage of a comprehensive character can be accomplished without cooperation among land owners. There are common interests involved that cannot be separated. The owner of land occupying a higher area than his neighbor sometimes has no outlet without crossing the land of his neighbor. If the drain so constructed will benefit his neighbor, the latter should bear a proportional part of the expense of the work done on his own land. A case can scarcely be found where the making of a drain for the benefit of upper land and conducting it through that occupying a lower level can work any injury to the lower land. It is in accordance with justice and equity, however, that the work of improving the upper land by artificial means should be done in such a way that no injury will result to anyone. Some farmers are unintentionally captious in cases where the improvements of a neighbor's land requires some concession on their part. At the same time there is great reluctance on the part of some to consider the rights of the owners of lower lands over or through which drainage must be obtained. Many misunderstandings in the adjustment of these matters arise from a misconception of the true office and results of land drainage in general.—(F. B. 187.)

Drainage of Irrigated Lands.—Where the evil of over-irrigation has been wrought, too much cannot be said in favor of a proper system of under-drainage. Even though a given farm many not be injured by alkali, seepage waters from this farm will arise upon farms lower down, bringing with them alkali salts, which, if allowed to accumulate, will ruin the land. Many of the western soils are hardly considered valuable enough to warrant extensive drainage; but drainage will have to be done sooner or later.—(Y. B. 1898.)

Irrigated lands needing drainage may be divided into three classes: (1) Those injured by excess of water only; (2) those affected by an excess of both water and alkali; and (3) those having an excess of alkali only. The first class is the least extensive of the three, the extent of injury depending upon the value of the crops that may be grown on the land when dry. The greatest danger of serious loss in this kind of land is that alkali may accumulate in injurious quantities with the lapse of time. In the irrigated region there is very little seepage water which does not contain some alkali in solution, which tends to accumulate to an injurious degree in saturated land. Inquiry into the history of lands which have become badly affected with both alkali and water show that when injury first became noticeable such lands could have been protected from further injury with as much profit as attended the reclamation of lands affected by water only. It is to the second class that most of the lands belong which now need drainage in the irrigated sections. Alkali accumulations usually follow accumulations of seepage water. If one admits that this condition is a forerunner of total abandonment, surely no argument is necessary to convince him that such lands belong to the class that should be drained. Lands of the third class are principally those in the virgin state, having enough alkali uniformly distributed through the soil to a depth of 6 feet to cause crop failure after a few years of irrigation, because of insufficient underdrainage. If irrigated lightly, the alkali will in time become concentrated at the surface, and if irrigated copiously, without underdrainage, water-logging will follow.—(F. B. 371.)

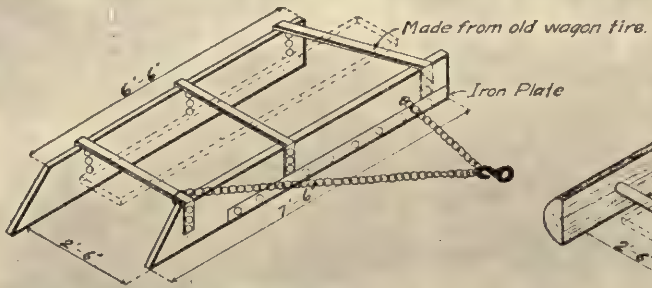
Necessity of Drainage.—Lands which up to a certain time have produced crops in quantity and quality to which no exception can be taken, may, without apparent cause, begin to deteriorate. Upon examination it will be found that the alkali salts have accumulated near the surface in such strength as to destroy crops that had previously been grown successfully. The need of drainage of such soils as a preventive of such injuries, as well as for a restoration of the land to its normal productive condition, is apparent. The subject has a peculiar significance to the owners of lands which have succumbed to the inroads of seepage. In sections of the country where irrigation is resorted to many a highly productive ranch has been seriously injured or wholly ruined by seepage. By drainage such lands may be reclaimed to a high state of fertility. The saturated condition of the land which shows injury is not due to the water which is applied directly to irrigate it, but to the surplus which percolates from higher land. The value of understanding the fundamental principles of drainage in preventing the injury of lands in irrigated sections, and reclaiming them to agricultural use, cannot be overestimated.—(F. B. 187; Rept. Office Ex. Sta. 1910; F. B. 371.)

Methods of Draining.—A series of small wells located at points where the water appears have proved effective in some sections.

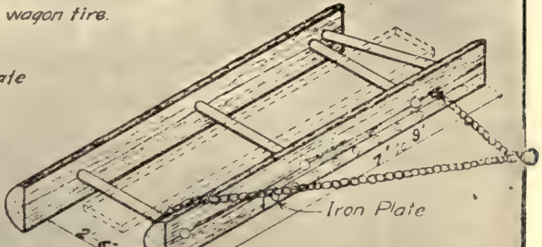
The wells consist of curb boxes 12 inches in diameter, made with eight sides, from boards 1 inch thick. They are sunk from 8 to 12 feet deep, the excavations being made with a large auger. The wells have underdrain outlets about 3 feet deep, leading to a surface ditch. The water rises at once in these wells to the height of the outlet provided and flows away. The soil, which is about 5 feet deep, is underlaid with gravel, which through the process of seepage from higher lands has become surcharged with water which by reason of constant pressure and continued supply from land occupying a higher level saturates the soil above the gravel. Its efficiency consists in relieving the pressure of the underground water at such a depth that it will not continue to force itself upward against the soil.

No little discussion has arisen concerning the utility of cement tile for draining seeped lands, especially those which are strongly charged with alkali. The scarcity of well-burned clay tile, as well as of good clay for manufacturing them, in regions where they are most needed, makes it desirable to use cement if it is possible to do so. The evidence furnished by tiles which have been in operation is conflicting, some having remained intact for 10 years and still manifest no sign of disintegration, while others apparently as well made have failed within a year. Those who have experience in the use of this material maintain that if tiles are molded from a mixture of one part good cement and three parts of the aggregate used in a wet state, they will resist injury by alkali. The varieties of alkaline salts which are found in seeped lands is so great, and their possible combinations are so numerous, that the use of cement tile for draining such lands is attended with considerable risk. Experience so far suggests that the pipes should be made dense and practically nonabsorptive if they are to be safely used in water which contains a considerable amount of alkaline salts from the soil. Even clay tiles which are soft or poorly burned should be discarded on the score of probable disintegration if they absorb water freely. What are known as seconds at sewer-pipe factories are excellent for draining and are quite commonly employed where tiles of large size are needed.

Wooden Box Drains.—The subject of material which is used for drains should not be passed without reference to wooden boxes, which, of necessity, are employed in many localities because more lasting material can not be obtained at a reasonable cost. They serve an excellent purpose while they last and have been exceedingly



Cut from a 2"x12"-14'-Plank.

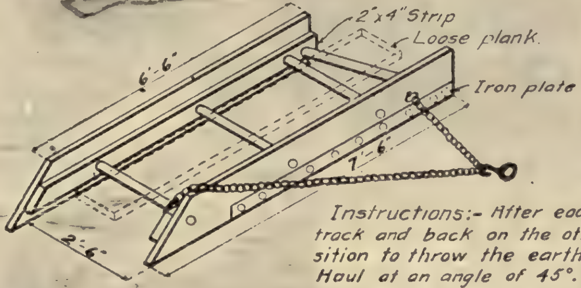


Made from a 10" to 12" log.

THREE PLANS
FOR
THE KING ROAD DRAG

IOWA HIGHWAY COMMISSION

May 1905.



Instructions:- After each rain drive up one side of the wheel track and back on the other side at least once, with drag in position to throw the earth to the center. Ride on the drag. Haul at an angle of 45°.

Gradually widen the strip dragged as the road improves.

To round up the road better, plow a shallow furrow occasionally each side of the dragged strip, and work the loose dirt to the center.

(See pages 149-165.)

useful in experimental drainage where the doubtful results of the experiment did not seem to warrant the use of more expensive material. They are made in rectangular form, with or without bottoms, according to the ground in which they are to be used.

The use of the open-bottom box, or tile, as an intercepting drain is of little or no value in gravel formations, especially where the surface slope is considerable. In the relief system the drains must be placed nearly parallel to the direction of flow of the ground waters, and the best results are secured when thus laid. More or less satisfactory results will be secured when the drain runs slightly oblique to the direction of the flow. The more nearly the line of the drain approaches a direction at right angles to the flow of the ground-waters, the less efficient will the drain prove.—(F. B. 187; Rept. Office Ex. Sta. 1910; Mont. Ag. Col. B. 76.)

Bogs.—The cultivated areas are frequently bordered on one or more sides by lands in which the shale is partially disintegrated and which convey the water from the higher irrigated land, or possibly from irrigating ditches, into the soil blanket, where it fills up the land so completely as to make a permanent bog. Not infrequently it is entirely impracticable to place a drain through the wet part of the field because of its extremely soft and unstable condition. At least a part of the water must be intercepted and prevented from entering the field before complete drainage can be effected. This is accomplished by placing a drain on the edge of the wet tract in such a way as to penetrate the shale which delivers the water.—(Mont. Col. Bul. 76.)

Maintenance.—Constant attention will be required to maintain open ditches in proper condition. They are subject to obstruction by the accumulation of weeds which the wind carries into them, and to filling by soil which is washed from the adjoining lands by waste water, when the fields are irrigated. Covered drains must also receive attention in soils which do not become compact and firm over the drain, for the reason that whenever the land is irrigated water will quickly find its way into the drain, carrying with it an amount of soil which will soon fill and obstruct it. This inconvenience and risk disappears as the earth with which the trench is filled becomes compacted, which condition is hastened if special care is taken in packing the earth at the time the trench is filled. —(Rept. Office Ex. Sta. 1910; F. B. 371.)

Seepage.—There are thousands of acres of some of the best agricultural lands in the Northwest becoming less productive because of the excessive moisture of the soil occasioned by seepage. The cause of seeped or oversaturated land is the waste from irrigation and leakage from canals and laterals. The skillful irrigator may insist that if no more water is applied than is needed for growing and maturing the crops, and that if the canals are so constructed that no substantial amount of water escapes into the earth, no land will become too wet for farming purposes. It is true that in many instances irrigators have been unduly prodigal in the use of water, particularly when the land is first subdued and watered. The art of economical irrigation is usually learned only when scarcity of water compels its less lavish use. In any event some waste of water will occur under the best of management, making draining in many places essential to profitable farming.—(Mont. Agr. Col. B. 76; Wyo. Ex. Sta. 61; Rept. Office Ex. Sta. 1910.)

Alkali.—On irrigated lands one of the objects of drainage is to rid the soil of an accumulating alkali which, if not removed eventually ruins the soil for productive purposes. A failure of his crops is frequently the first intimation to the farmer that his soil is too wet and that alkali in harmful quantities is present. Effective drainage removes the cause of the accumulation, yet special treatment is frequently required to remove the excess of alkali sufficiently for growing crops. Copious irrigation, followed by thorough and deep cultivation and the growing of alkali-resistant crops for a season or two, quite commonly restores the land to its former productive condition. Some fields, however, are so fully charged with salts, due to seepage and to neglect in the use of preventive measures, that a longer treatment by various methods of flooding, in connection with the relief that is furnished by drainage, is required. Complete drainage, however, is the first essential in such reclamation, but should be followed by liberal irrigation until the alkali has been removed sufficiently to permit the soil to grow a crop, after which the quantity of water may be adjusted to the actual needs of the crops which are to be grown. No fact has been more thoroughly developed or forcibly emphasized by drainage experiments and ordinary field practice than the value of timely attention to this subject as a preventive of seeped and boggy fields. The harmful deposition of alkali is generally from one of three causes:

1st. Light rainfall, insufficient to wash out and transport the harmful salts by surface run-off; which condition is strikingly prevalent in the Rocky Mountains West. 2nd. Poor drainage, principally a lack of underground channels whereby water containing the alkalis in solution is allowed to stagnate and perforce eventually approach the surface. 3d. Excessive surface evaporation, inducing a concentration and lodgment of salts at the root crowns of plants. The source of alkali may be found primarily in the particular soils themselves, or carried from soils so affected by the irrigation water used.

The ground waters passing through the lower formations take up these salts and hold them in solution. When the ground water reaches a point near the surface evaporation takes place removing the water and leaving the alkali deposits upon the surface. The productive power of the soil is thus lessened by excessive moisture, and the consequent shutting out of air, and this impregnation of alkali salts. The plans of treating land for the purpose of redeeming it from alkali which has accumulated through evaporation and seepage are not uniform, nor is there any practice which has been so reduced to a system as to justify an authoritative statement of methods that may be best employed. The cutting off of the underground supply by drainage has often resulted in the full reclamation of the land, with no other treatment than subsequent irrigation and cropping. In other instances, more complete underdrainage and special irrigation with cultivation for two or more years has been found necessary.—(Mont. Ag. Col. B. 76; F. B. 371; Wyo. Ex. Sta. B. 61; Rept. Off. Ex. Sta. 1910.)

Objects of Reclamation.—Reclamation has another purpose than rendering more fertile the soil that is already under cultivation. In nearly every State are large tracts of land known as marsh or swamplands, and of lands subject to overflow to an extent that renders cultivation unprofitable if not altogether impossible. In the single State of Wisconsin alone it is reported that there are 7,000,000 acres of land in need of drainage, of which 2,500,000 acres are marshlands.—(Rept. Off. Ex. Sta. 1906.) This condition prevails to a greater or less extent in other States. Under the rapid increase of city population and the growing scarcity of good agricultural lands, the reclamation of these marsh and overflowed lands has become a necessity. When reclaimed the soil of these lands has been found to be of the greatest fertility. The importance of this reclamation as a sanitary measure cannot be overestimated. It is evident that the drainage conditions on an area may be improved either by hindering the entrance of damaging water upon one side, or by facilitating its removal from the other. To accomplish one or both of these improvements drains must be constructed which will give gravity a better opportunity to remove surplus water.

Methods of Reclaiming.—The methods of reclaiming these lands so far as they have been tried in this country, are by means of ditches or canals, subdrainage with tile, building of dikes and levees, and the use of pumps for disposing of the surplus water, and by deepening and widening natural channels. In some instances individual owners have either constructed ditches, dikes and levees for the reclamation of this land or to protect it from overflows; in other cases adjoining owners have united in this work, but nearly all the large systems have been constructed either by the States or the Federal Government. These waste places, rich in fertility and having an ample supply of moisture for plant growth, only need draining to enable heat and air to penetrate the ground to make them ideal locations for truck gardening on a large scale. Many of these are so situated as to offer economy in transportation which furnishes another important reason for their early reclamation. Either by rail or boat products can be landed cheaply and quickly in the market places of large cities or thriving towns at very little cost. This adds greatly to the commercial value of the land and allows for a much more liberal expenditure for reclamation than could be borne if there had to be added to the cost of production the cost of a long-distance haul to market.

Drainage Design.—A consideration of the greatest importance to the individual owner or to a community of owners is that the ditches, canals, dikes or levees are large enough for the purpose intended, and that they are built substantially and permanently. Nowhere is the old maxim, Whatever is worth doing is worth doing well, more forcibly illustrated than in the building of dikes and levees. The design and construction of the levees, ditches, and pumping plant require a considerable degree of engineering ability. Poor design may result either in a system so inadequate for its purpose as to yield a benefit to the land insufficient to make the undertaking profitable, or it may lead to an expenditure for construction greatly in excess of the amount that could have been made to suffice. In general, the inexperienced tend to underestimate greatly the extent and expense of the work required in such reclamation.

The levees must originally be made of such height and thickness as to afford ample strength and they must also be given careful subsequent attention to secure proper maintenance. The internal drainage ditches should be deep enough to keep the ground water level at least 3 feet below the surface and their capacity should be sufficient to discharge heavy rains freely to the pumping station. Streams entering the district from higher ground should be diverted around the levees where such a plan is feasible.

The pumping plant should have a capacity sufficient to remove as a minimum amount in 24 hours a quantity of water sufficient to cover the entire district to a depth of one-fourth inch. The capacity should be greater in situations of heavy rainfall and where the run-off of rolling land is received in the district. The pumping machinery should be so arranged as to reduce to a minimum the work of disposing of the surplus water, and it should be chosen with especial regard to economy and efficiency.

The strip of land occupied by the levee should not be located too close to the natural banks of the stream whose waters are to be diked off. Consideration must be given to the question of leaving outside the levee a sufficiently wide flood channel. The conclusion reached in any particular case will depend upon the conditions existing upon the opposite banks of the stream, and no definite rules can be stated. If the banks of the stream are subject to cutting or caving, the question of the future permanence of the levee enters. A strip of timber should be left outside the borrow pit to form a protection to the levee during high water against erosion by too strong a current, and against destructive wave action during high winds. Where practicable, bars across the borrow pit should be left at intervals so as to prevent too strong a current near the levee. No sharp corners should be made in the line of the levee's location.

System of Ditches.—In planning a system of ditches it should be the aim to locate them in such a way as to leave the land in the best possible shape for cultivation. Where there is high land that drains into the marsh, an intercepting ditch should be cut along the foot of the slope to lead the water into the storage basin without overflowing the low land. The depth of the ditches required and their distance apart depend largely upon the character of the soil. The main ditch should be as deep as the sill of the tide gate, while the laterals should range from 2½ feet deep at the upper end to 3 or 3½ feet at the lower end, according to the depth of the outlet channel. In most places ditches in marsh soil will stand with almost perpendicular banks, owing to the fibrous roots in the material, so to increase the storage capacity they should have wide bottoms, with bank slopes one-half horizontal to 1 perpendicular, unless places should be found where the material requires a greater slope. It is not practicable to give specific directions for laying out a system of internal drainage, as each marsh must be viewed and treated according to its shape and peculiar location.

One of the first problems to be disposed of in considering a project for the improvement of overflowed lands is the disposal of the storm water which comes from the higher lands back of the district. Where there are wide bottoms along streams having good falls it is often practicable to carry both the hill and the storm water of the district in a channel extending for a long distance near the foot of the bluff and parallel to the main river, finally discharging it at the lower end of the levee into the main stream.

Outlet ditches are those which are large enough to remove flood water from an area and deep enough to afford underdrainage either directly or by affording outlets to covered underdrains. Since they carry water practically all the time, they may be called wet ditches. Surface ditches are intended only to conduct surface water to outlet ditches or to natural outlets. Since they are of use only during flood flow, they are dry most of the time, and may be called dry ditches.

The capacity of a drain is the greatest discharge that is possible, and the requirement is the greatest discharge that is necessary. In designing a drain so that the capacity shall equal or exceed the requirement, the depth, size, and gradient are perhaps the greatest factors to be considered. Conditions in these respects that are permissible or necessary in one type of drain may not be so in the others.—(Rept. 9 Irr. and Drain.; Wis. Ex. Sta. B. 199.)

Levees.—The care of levees subsequent to their completion is an important matter too often neglected. The slopes should be smoothed and as soon as practicable a good growth of grass should be secured. For this purpose bluegrass, Bermuda grass, redtop, timothy, and clover are all used. A good growth of sod will hold the soil in place and prevent erosion. A mowing machine can be used on a 3 to 1 slope, but scarcely on a steeper slope. On a steeper slope, too, beating rains are likely slowly to wash out the soil and thus gradually reduce the height of the cross section. All weeds and brush on a levee should be cut at least twice during the growing season, as they are particularly harmful, loosening and disintegrating the soil by their roots. Sometimes the top of a levee is used as a road, but this practice is not to be commended, for the wagon wheels cut off the corner of the top and the ruts likely to be formed grow rapidly to such dimensions as seriously to affect the height and efficiency of the levee. The proper place for a road along a levee is on the level ground just inside the inner toe. Burrowing animals of numerous sorts are a constant menace to the integrity of a levee, and they should be assiduously hunted and driven away. Frequently levees are pastured. This has the advantage of keeping down the vegetation, keeping the soil compacted, and driving away burrowing animals. The slight damage to a levee which may result from using it as a pasture is easily observed and repaired and is probably counterbalanced by the good results of the practice.

The surface washing of hillsides results in great loss to farmers by depleting the fertility of the cultivated land, not infrequently causing the abandonment of entire fields to weeds, briers and broom grass. The terrace system which is commonly employed to prevent washing consists of a series of small ridges constructed across the slope on contour lines at intervals the width of which depends upon the degree of the surface slope. These ridges are sometimes placed as close together as 20 feet. As the ridges are at least 4 feet in width, 16 per cent of the land is thus occupied. It is not uncommon to find entire fields terraced at 100-foot intervals, in which cases 4 per cent of the land is occupied by the ridges. The object of their construction is to retain the rainfall until it can pass into the soil by slow percolation. In some cases the trench on the upper side of the terrace is given a gentle grade for the purpose of leading the water to some point where it can be taken to the stream at the foot of the slope. The ridges serve as a series of small dams which, when they break, as they frequently do, cause the water to wash away considerable soil, and break one or more of the terraces below. Such breaks often open out washes during a single rainstorm, which are costly to repair and which, if neglected, seriously injure the field. The permeability of hill-land soil to water varies greatly, as does the slope and contour of the surface. Farmers usually vary but little their practice of terracing, applying the same system of construction to all hill lands.—(Wis. Ex. Sta. B. 199; Rept. Off. Ex. Sta. 1906; Ex. Sta. B. 243; Rept. Off. Ex. Sta. 1909.)

Failures.—Experience has shown that the stability of a levee is dependent upon its location, cross section, material used in construction, and maintenance. If all these conditions were ideal there would be no levee failures, but in practice it is not often possible to get them. Locations must be used which leave the foundation and slopes exposed to erosion by currents and waves. Such material as is at hand must be used, and the funds available often determine the size of the cross section. The ideal material for levee construction is a heavy tenacious earth which will not erode or dissolve when subjected to the direct action of water and will resist percolation under hydrostatic pressure. Of the available materials found in river bottoms gumbo and buckshot are the best. In many places complaints are made of the ravages of muskrats. It is stated that they burrow in the embankment and cause it to give way during periods of high water. This trouble can be greatly lessened, if not entirely avoided, by keeping the embankment free from a rank growth of vegetation. It should be mowed at least twice a year and the material cut at once removed. This will destroy the harbor for these animals, and the damage they do can be more readily detected and repaired. Where an embankment is constructed by a number of landowners there seems to be a division of responsibility, and no one looks after it and it does not receive the care necessary for its protection and security. —(Rept. Irr. & Drain. 1906.)

Wherever land reclamation has been carried out on an extensive scale and in a thorough manner, some or all of the following benefits have been obtained: The greater certainty of a full crop; increase in acreage and also in the yield per acre; a permanent increase in the market value of the land; benefits to the public roads; benefits to railroads because of increased tonnage of freight; benefits to nearby towns because of increased business; benefits to public health and general welfare.—(Wyo. Ex. Sta. B. 199.)

Dunes.—In some sections of the country large areas of tillable lands are threatened with ruin from shifting sands in what are called simply dunes or sand-dunes. This sand is loose and the high winds which prevail at certain seasons of the year take up this loose sand and scatter it over the surrounding country, sometimes to such a depth as to wholly destroy the fertility of the soil. These dunes are not capable of cultivation, that is the returns would be so small as to render any attempt to cultivate unprofitable. The only thing left is to protect the adjacent lands from the shifting of the dunes. In some sections this has been a serious problem for many years and various experiments have been tried, none having proved wholly successful. The system that has most nearly approached success involves heavily planting the dunes with some hardy grass that will thrive on the sand, and at the same time produce thick, matted roots that will hold the sand from the winds. Reforesting has also been resorted to, but all trees will not grow under the conditions prevailing in these sand areas. In reclaiming the dunes around Cape Cod, Massachusetts, the following trees have been found the most successful: pines, pitch pine *(Pinus rigida)*, Austrian pine *(P. laricio)*, and Scotch pine *(P. sylvestris)* are proved successes. The pitch pine is used most extensively, as it grows naturally in the adjacent forests, and young trees and cones can be obtained in almost unlimited quantities. The black locust *(Robinia pseudacacia)* and the European or black alder *(Alnus glutinosa)*, though not occupying extensive areas, have proved thoroughly adapted to the conditions, and it is the plan to increase the plantings of these two species. The Scotch broom (*Cytisus scoparius*) is well adapted to the conditions with the one exception of not being perfectly hardy, as many small areas have been killed by one or two excessively cold winters, though much of the original planting is still alive and vigorous. The plant does not spread readily from seed, as the severe conditions prohibit its existence in the early seedling stage, and furthermore, the seed being large and conspicuous is readily eaten by birds and small animals. The growth is very dense, and even scattered bunches would prevent the sand from shifting, but its semihardiness makes it decidedly inferior to the bayberry, which is locally abundant, perfectly hardy, and easily transplanted. The bayberry has formed the bulk of the pioneer plantings of woody growth, and used in connection with the beach grass appears to be the only necessary forerunner of the pines.—(Bu. Plant Ind. B. 65.)

Beach grass has been found the best adapted to grass planting. No grass that is not hardy enough to live in the sand and will not produce thick and matted roots will succeed. Another plan has been to cover the dunes with a thick layer of brush.

IRRIGATION.

Irrigation should be recognized as an agricultural art of very wide applicability and value. Its association with the idea of desert reclamation has blinded the public mind to its value for regions where the need of reclamation does not exist. Irrigation is a means of soil improvement to be employed, like other means of improvement, when the soil needs it. Water is the most important food of plants, not alone because it enters in such volume into their tissues, but because without it in adequate amount the plant can not use other foods in sufficient quantity. No one questions the wisdom of the saving and storing of manures, nor the wisdom of generous outlay for commercial fertilizers when required. The same is true of soil improvement by means of drainage. There should be a similar feeling in regard to irrigation.

The most diligent culture and the most generous fertilization are often made of no avail, and actual loss is sometimes incurred because the farmer has not prepared himself to supply water when needed. The water, which he could often provide for a mere fraction of his expenditure for fertilizers, often for less annual cost than the interest on his investment in underdrainage, he has neglected to have ready for use, and he sees the hope of return for his year's labor and expenditure fade away during a few weeks of drought. There have been cases where water has been stored at considerable expense as a protection against fire in barns and has remained unused while some valuable crop was burning up in the garden. Such losses are largely due to two things: First, the notion that irrigation is of importance only in arid regions; and, second, ignorance of the ease and cheapness with which a farm water supply can be stored and distributed. It is very important that the value and availability of water for irrigation should be recognized and a supply provided on each farm.

Under our present modes of cultivation the farmer can do little for the crop during the time of actual drought. Ordinary cultivation is of comparatively little benefit during a prolonged dry season. Its most effective work is before the dry spell sets in. No matter what the value of the crop, and no matter how much this value is concentrated on small areas of land, there is practically but little to be done to save the crop. Irrigation should be used as an insurance against the loss of crops. A small pond fed by a windmill would often save a garden or a small area of a valuable crop from destruction or great injury during a dry season. A small portable farm engine, which would be available at other times for cutting feed, thrashing grain, and other farm purposes, could be used to drive an irrigating pump during the dry seasons. This would be particularly valuable for tobacco, truck, and other crops which are grown under a very intensive system of cultivation.

The need of irrigation in any region, arid or humid, is determined, not by the total amount of rainfall occurring during the year, but by its distribution throughout the year; in other words, by the amount of rainfall occurring in the crop-growing season, May to October, during which period the warmth and light of the sun's rays are most effective. In the humid portion of the United States, even in localities in Florida where they have from 60 to 70 inches of annual rainfall, irrigation is used successfully as a means of insuring the crop against drought due to the uneven distribution of the rainfall.

In these regions, however, irrigation is not so necessary to profitable agriculture, as it is in the West, and the problem is not how to get the largest possible returns from a limited water supply, but whether the supplying of water to plants during dry seasons or during the short dry periods which occur in almost every season will increase production enough to repay the expense incurred. This, of course, includes a study of the most economical means of securing a water supply and the best methods of applying it to crops. Experiments made in Missouri, Wisconsin, and New Jersey have demonstrated that irrigation in those sections is highly profitable. The work in Missouri is mainly with small fruits and nursery stock. The experiments in Wisconsin include field as well as garden crops, and at present the irrigation of cranberries is being thoroughly tested. In New Jersey small fruits and garden crops have been irrigated with success.

Irrigation is most extensively practiced in the growing of fall, winter, and spring truck crops along the Atlantic coast from Virginia to Florida. The prevailing methods of application are by sprinkling and through underground pipes, both of which are very expensive. If cheaper methods can be made to serve equally well, the saving to the truck growers will be very great.

The greatest field for irrigation in the humid district is, however, in the Southern States. Here extensive systems of irrigation from wells or streams by pumping have been established.

Irrigation is not merely a recourse to insure the safety of a crop. It has been demonstrated beyond question both by practical experience and by systematic experiment that growth and production can be profitably pushed by irrigation even when the natural moisture seems ample, and in this respect irrigation aligns itself with fertilization and cultivation as a factor in intensive culture.

Another error grows out of the large scale upon which irrigation is generally known to be carried on, involving canals and ditches too expensive for individual undertaking. The impression is made that considerable capital and engineering skill are necessary to success; but as a matter of fact profitable irrigation is easily attainable by small effort. It lends itself readily to small individual or co-operative undertaking, developing water whose presence may be almost unsuspected, or utilizing water which ordinarily is either wasted or is a positive detriment when not turned to profitable service.—(F. B. 138; Ex. S. 1904; Y. B. 1895; Ex. S. A. R. 1908, and Cir. 226.)

In choosing land which is to be irrigated a careful examination should be made of the character and depth of the soil, its behavior when irrigated, the slope and evenness of the surface, the presence of injurious salts, and the facilities for drainage. One of the best indications of the character of the soil is the native vegetation which grows on it. When sagebrush, buffalo grass, or cactus is found on a tract, it is reasonably certain that the soil is fertile, easily tilled, and well drained. The plants named are but a few out of a large group which grow on good soil, easily irrigated. On the other hand, the presence of greasewood, saltwort, salt weeds, or other similar plants is indicative of a heavier soil, less easily cultivated, and containing more or less of the injurious salts usually grouped under the common name of alkali.

In arid regions cultivated plants are deep rooted. They draw their supply of plant food and moisture from considerable depths, and the deeper the soil the larger is the feeding ground for the roots and the greater is the capacity to store water. In the warmer parts of the West the top layer of soil is used chiefly as a sort of blanket to protect the moist soil beneath, which furnishes both food and water to the fibrous roots. The presence of any hard, impervious stratum lying between the first and fifth foot prevents deep rooting and the storage of moisture. A hard stratum lying between the fifth and tenth foot is likewise injurious, but to a less extent. On the other hand, a porous stratum of coarse gravel may waste large quantities of irrigation water by permitting it to percolate beyond the root zone. It, however, insures good drainage, and is more desirable than an impervious subsoil. The character of the subsoil may be readily determined by boring holes with a suitable soil auger to a depth of 10 feet, if necessary, and taking samples of soil at different depths.

Absorption of Water by the Soil.—Easily irrigated soil will absorb sufficient water in twenty-four hours after an irrigation to become moist to a depth of 2 or 3 feet. Some soils are so impervious that it is difficult to wet more than a few inches below the surface and others are so porous that the water soon percolates through them beyond the reach of the deepest roots. The surface of other soils bakes and cracks after each wetting, which renders cultivation difficult. It will usually be possible to find similar soils under irrigation in near-by fields, but if this is not possible, a trial may be made on a small scale to determine how the soil acts under irrigation. In general, sandy loams irrigate well, while clay is hard to cultivate when wet, does not absorb water readily, and bakes and cracks when drying.

Surface Conditions.—The farmer should likewise examine with much care the nature of the ground surface. The best conditions are a smooth surface, with a uniform slope of 10 to 20 feet to the mile. Such land costs little to put in shape for the spreading of water over it, and the slope insures good drainage. At the other extreme, one finds land full of buffalo or hog wallows. These alternating heights and hollows are difficult to reduce to an even grade. Again, the land may be cut up by ravines, thereby increasing the labor and cost of putting water upon it, or it may have too much or too little slope. If land which is naturally smooth on the surface and of the right slope costs $5 per acre to put in shape for irrigating, hog-wallow land may cost $15. Thus it is evident that the cost of preparing the surface is an important consideration in the first cost of the land. Besides, some hog-wallow land is inferior in quality, being frequently charged with injurious salts.—(F. B. 263.)

Irrigation Waters.—The injurious effect of irrigation water is due to the presence of such alkaline bases as soda, potash, ammonia. These usually appear as sulphate of soda (Glauber's salt), and carbonate of soda (salsoda). Sulphate of potash, phosphate of soda, nitrate of soda, and carbonate of ammonia rarely occur in underground waters. Quantity considered, carbonate of soda is the most injurious of the mineral elements, from an irrigation standpoint, found in our water supply. This form of soda combines in many cases with vegetable mould or humus forming a black compound when dry, known as black alkali.—(Tex. Bul. 43.)

The best method of distributing alkaline accumulations is by flooding, thereby lessening the concentration of the salts to an uninjurious degree. This may be done by growing crops upon affected ground requiring irrigation by flooding, as alfalfa; or by using (preferably) fresh river waters, where available, in sufficient amount to effect the distribution or removal of salts.

The rise of the alkali from the use of salty irrigating waters may be controlled in large part, where practicable, by deep irrigation, especially through subsoiler furrows. This method economizes water by lessening surface evaporation, and at the same time hinders the accumulation of salts at the surface.

Deep and thorough cultivation must follow and supplement deep irrigation, as this prevents the return of salts to the surface. —(Ariz. Sta. Bul. 44.)

Experience throughout the arid region is demonstrating that the greatest danger to irrigated lands is lack of drainage. Water applied to crops raises the ground water, which brings with it the salts dissolved from the soil; capillarity brings this water to the surface, where it evaporates, leaving the salts to accumulate until all vegetation is destroyed. The only insurance against this is proper drainage. The drainage conditions are therefore equally important with the water supply and should be looked into with as much care. When there is not good natural drainage it must be supplied artificially. This, usually, is as expensive as securing the water supply. —(F. B. 263.)

The sources of water supply and methods of use most frequently available for a single farm include the following: Diversion of perennial streams; development in dry stream beds; development of springs; catchment from outcroppings of water-bearing strata; tunneling to intercept such strata when deeply covered; flowing wells; pumping from wells, lakes, or streams, and storage of storm water from surface flow or from drainage systems.

Diversion from Streams.—Diversion from perennial streams is the most common method of securing irrigation water, and it is available for either great or small undertakings wherever unappropriated water flows in sufficient amount.

After assuring himself that a near-by stream carries sufficient water for his purpose, the next step for the farmer is to determine whether the water can be brought to his land at a reasonable expense. This will depend principally upon the length of the ditch which must be constructed. The simplest way to find out how long the ditch must be is to run a line having the necessary grade from the highest point of the land to be irrigated upstream till it strikes the stream. The grade on which the ditch should be built, and consequently upon which this preliminary line should be run, will depend upon the quantity of water to be carried and the nature of the soil over which the ditch will run. In general, the larger the ditch and the lighter the soil the smaller the fall which can be given to the ditch; and the shorter the ditch the smaller the fall. However, the grade should not be too light, for the ditch may have to be made larger to carry the desired supply of water. On the other hand, the grade can not be very heavy or the strong current will wear away the ditch banks. Therefore the range of the grades which may be given to a ditch is limited. In ordinary soils a grade of 2 inches in 100 feet may be given to small ditches, and in clay soils as much as 3 to 5 inches in 100 feet may be given.

Should the line run in this way be too long, the stream below the point where the line strikes it should be examined to see if there is any place where the water can be raised by a dam high enough to flow into the proposed ditch. In case no such place is found, a water supply from that source must be abandoned.

Building the Ditch.—Having decided upon the point of diversion and located the ditch line, the farmer is ready to build the ditch. The line of the ditch should first be marked by a furrow. To do this, let one man guide the team, walking between the heads of the horses, holding a bit in each hand while another holds the plow. The furrow should be turned to the lower side of the ditch. If the surface of the ground is comparatively level across the line of the ditch, it is not necessary to follow the stakes closely in the bends. The ditch will be better for being straightened a little, which may be done by going above the stakes that locate the bends nearest the stream and below the stakes farthest away. If the ground slopes very much across the ditch line the stakes must be followed closely. After the line is marked, two or three furrows are plowed, all being turned to the lower side. A farm ditch can be made almost wholly with an ordinary plow by going over the line a number of times. The loose earth in the bottom of the ditch may be removed with a scraper or shovels.

A small stream can be easily diverted into a ditch, if it is running in a shallow bed, by a cross-stream dam of posts and plank, of posts and brush, of brush and rock or cobbles. Such structures are not usually water-tight, but they will raise the water to the level of outflow into the ditch which is to carry it to the land to be irrigated or to the reservoir from which it is to be distributed. A better dam, either of masonry or of earth, made water-tight by a puddle-bar of clay, may last for a long time in a small stream if adequate arrangements are made for the passage of waste and flood water.

Raising a small stream in a bed requires a dam of greater strength. In such cases it is safer to make the dam of timber or masonry arching upstream, bedded well into the banks, and puddled well above with clay, to prevent leakage, which would soon undermine and carry down an otherwise good structure. Such a dam will cause the bed of the stream above it to fill with sediment, which will reduce the direct pressure.

Location of the Head Gate.—At the point of diversion from the stream a head gate should be put in. This is a very simple construction of plank with a sliding gate capable of being raised and lowered. It will protect the ditch by keeping the water out in time of high water. It should have a cross plank on the stream end, so that the water shall fall over the plank, as this will prevent much heavy sediment from entering the ditch. Obviously the dam must raise the water sufficiently to surmount this obstruction.—(F. B. 138.)

On the quality of soil through which the ditch must be constructed depend the permanency of its channel, the rate of velocity at which water can safely be carried, the cost of first construction and the economic value of the ditch as a water carrier.—(Y. B. 1900.)

The cost of building these ditches is variously estimated at from 25 to 50 cents per rod, depending on the local conditions, amount of fluming, etc., though a close estimate is hard to form. The expense of cleaning and maintaining them is about $25 per year for each quarter section, or, as some have apportioned it, 20 cents per acre for each acre under the ditch.—(Ex. S. Bul. 133.)

Proper Location of Ditches.—Farm ditches should be located in the right place at the start. It is a mistake to build ditches for the lower part of a farm and then in after years, when there is a desire to irrigate the remainder, to be obliged to build a second series of ditches for the higher land. Sufficient water should first be conveyed from the canal or other source of supply to the highest point and from there distributed to the various subdivisions. In laying out these permanent ditches an effort should be made to locate them along field or fence boundaries, if possible, in order not to obstruct the passage of teams and implements in fields. When the grade is too steep to permit this a curved location through fields should be chosen.

Ditches on Uneven Land.—It often happens that a farm is more or less cut up by ravines or depressions which intersect or separate fields, and the supply ditches have to be extended across these low places. This is usually done in one of three ways. When the depression is not more than a few feet deep levees are built on each side; in other cases flumes are built on grade from side to side, and, lastly, the water may be carried across in a pipe laid in the form of an inverted siphon. The earth levee is the cheapest, but it is subject to leaks and washouts for the first few years. The wooden flume answers the purpose fairly well, but it is subject to early decay, and the clay or cement pipe laid beneath the surface, although dearer in first cost, is really the cheapest in the end.

Preparation of the Land.—The preparation of the land for irrigation should follow the building of supply ditches. While this rule is frequently disregarded it will be found better to grade land in conformity to permanent ditches already constructed than to locate and excavate ditches to suit land that has been graded and leveled.

Importance of Surface Preparation.—The new settler in an irrigated district seldom appreciates the importance of preparing the surfaces of fields so that they may be cheaply, easily, and properly watered. Crops in an arid climate are as a rule good or bad, according as they have received the proper amount of water at the right time, and when the ground is left so rough and uneven that water can not be evenly applied the effect is shown in the reduced yield. The preparation of the land is a first cost, and if done thoroughly during the first or second year little expense need be incurred afterwards. The difference in cost between a smooth, well-graded field and one which is poorly graded and rough may not exceed $5 per acre, yet this sum is often lost in one season by diminished yields due to imperfect watering, caused by a rough, uneven surface. Thorough preparation of the surface applies with particular force to a crop like alfalfa, which grows year after year from the roots, and which is cut from three to six times each season.

Clearing the Surface.—Tracts which produce native grasses, low cacti, rabbit brush, and the smaller forms of brush can be readily plowed without first removing the larger plants. Such land should be plowed deep, the larger growth afterwards removed and the surface thoroughly harrowed, graded, and smoothed. In plowing for the first time, 2 acres is a fair day's work for a man and three horses, and the cost of removing the larger plants seldom exceeds 50 cents an acre. Tracts which produce tall, coarse sagebrush from 3 to 5 feet high, in clumps from 4 to 8 feet apart, with more or less nutritious grasses growing in the open spaces, are more difficult to put in shape for irrigation.

The brush is first railed by dragging a 60-pound rail from 12 to 16 feet long across and back over the same strip in opposite directions by hitching a team of horses or mules to each end. Sometimes the rail is bolted to a heavy timber. Others use a chisel-sharpened plowshare steel bolted to a 12 by 12 inch timber and dispense with the rail. The loose brush is then gathered into windrows or piles by a brush rake and burned. These rakes are made either of wood with teeth of round oak or pine joists or of steel and resembling a strong and heavy self-dumping hayrake. The brush which is not torn out by the rail is grubbed out with a mattock.

Cost of Clearing the Surface.—The cost of removing and burning a heavy growth of brush in the manner just described is about $2.50 per acre. Brush which grows from 2 to 3 feet high in clumps about 8 feet apart can usually be removed and burned for $1.50 or less per acre. When sagebrush is grubbed out by hand the cost varies from $1.50 to $3 per acre, according as the growth is light or heavy. In localities where water is cheap and abundant sagebrush may be killed by being flooded, and when dry is readily raked into heaps and burned.

Grading.—Land in the mountain States is first leveled, then graded and smoothed, and afterwards ditched. A supply ditch is first dug to convey water to the highest corner of the field, and permanent ditches are extended along one or two boundaries and occasionally within the interior of field. The land is then deeply plowed and well graded.

Field Laterals.—When a field has been leveled and graded, small ditches, called field laterals, are run through it. This work may be done either before or after seeding. On fields intended for alfalfa or meadows the laterals are made larger and with more care. They are usually located on a grade of from one-half to three-fourths of an inch to the rod, and are spaced about 75 feet apart in grain fields, and down the steepest slope from the supply ditch. Small laterals may be made with a common walking plow, but a lister plow attached to a sulky frame is to be preferred for medium-size ditches. The larger laterals, designed to carry 200 miner's inches, may be easily made by riveting together two steel beam plows, one with a right and the other with a left hand share. This method appeals to the poor settler, because it is less costly than most others. The cost of grading the surface in this way and building field ditches will vary from $2 to $5 per acre, depending on the natural condition of the land in its raw state.—(F. B. 263.)

Cost.—The cost of preparing land for irrigation varies with the condition of the ground and the price of labor. An approximate estimate, including the cost of removing sagebrush, plowing, harrowing, and grading, has been made. The cost of grubbing sagebrush is based upon the supposition that one man can grub an acre a day. The contract price for such work is $1.50 an acre.

The cost of grading land depends upon the condition of the surface, but, after thoroughly plowing and harrowing, $1 per acre for grading would probably cover the cost in most cases. Thus to prepare land for irrigation the cost would sum up as follows:

	Per acre.
Grubbing sagebrush	$1.50
Plowing	2.50
Harrowing	.50
Grading	1.00
Total	$5.50

—(Exp. S. Bul. 145.)

The cost of leveling depends altogether upon the character of the land, some tracts requiring a great deal more work than others. However, from the most favorable conditions to the most unfavorable under which leveling is done, the cost ranges from about $5 to $25 per acre, with the average between $12 and $17.—(Ex. S. Cir. 188.)

Choice of an Irrigation Method.—The choice of method is to be made in accordance with several conditions:

(1) The slope of the land.
(2) The character of the crop.
(3) The character of the soil.
(4) The labor requirement.
(5) Ease of cultivation after irrigation.—(F. B. 138.)

Methods of Applying Water.—The methods in which application is made in field and garden practice include the following:

(1) Free flooding, or running water without restraint except that afforded by the banks of the laterals conveying it.

(2) Flooding in contour checks, or irregular-shaped inclosures which are determined in size and shape by the inequalities of the surface.

(3) Flooding in rectangular checks, or inclosures which are approximately of equal size and with level bottoms.

(4) Depressed beds, with raised ditches on the levees which hold the water until it soaks away among the inclosed plants—a garden modification of the rectangular-check system.

(5) Ridge irrigation, in which plants are grown on the sides or at the bases of raised ditches—a simple form of depressed-bed irrigation.

(6) Furrow flowing, or running water in one or more furrows between the rows of crops grown in that way.

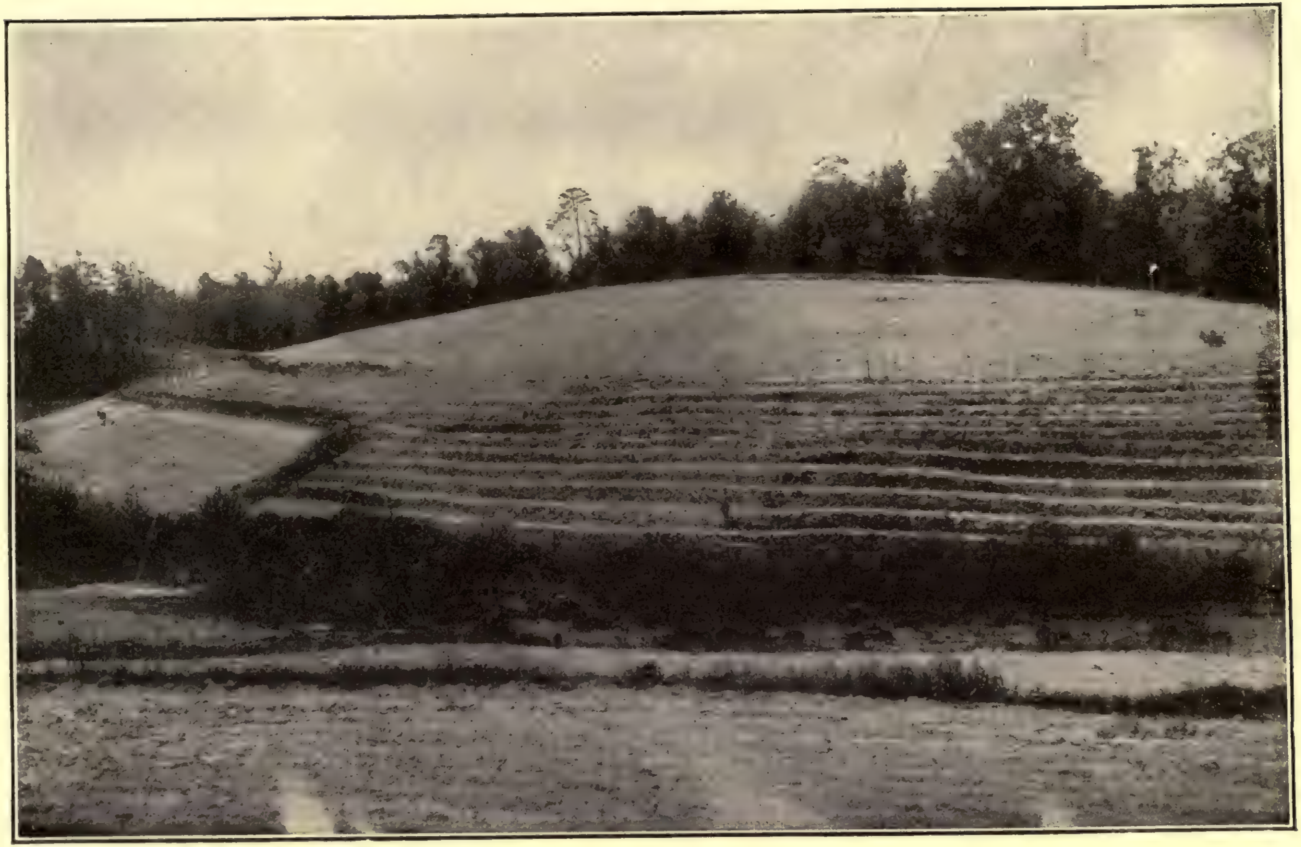
(7) Raised-bed irrigation, in which the water is taken by seepage and capillary action from a small ditch on each side—a modification of the furrow system.

(8) Subirrigation, or distribution by means of pipes with suitable outlets, or from blind ditches filled with material permitting circulation of water which will reach the plant roots by capillary action.

(9) Underflow irrigation, by which the ground water is raised by percolation from ditches at intervals of considerable distance—the plant roots being reached directly or by capillary movement.

(10) Distribution under pressure in underground pipes, with standpipes and connections for sprinkling.—(Ex. S. Bul. 145.)

Flooding Method.—Flooding the surface of land from field ditches or laterals is the most common way of wetting soil. This method is common in the Rocky Mountain States, and the conditions which prevail there seem to be well adapted to this mode of applying water. It can be used on quite steep slopes and in various other ways fits in with the requirements of the irrigator on the more elevated lands. It consists in leveling, grading, and smoothing the surface of fields to such a degree that water will readily flow over it. As a means of distributing the water over the field small



A Contoured and Partly Terraced Field. Dept. of Agr.

ditches or laterals are located along the best routes. These form a network of channels which cut up the field into small strips, which are usually from 50 to 100 or more feet in width. Custom differs as to the direction of these field ditches. Sometimes they extend down the steepest slope of the field regardless of the fall, at other times they follow grade lines and extend from the head ditch in more or less curved lines across the field.

In preparing a field for this method it is first plowed and harrowed and then graded. When the ditches extend down the steepest slope of the field they are located by eye, but when they are located on grade lines some kind of a surveying instrument is frequently required to establish the grades. A suitable fall for these small channels is one-half to three-fourths inch to the rod.—(Y. B. 1909.)

In cases where the extra expense is warranted, small wooden head gates may be used in diverting the flow from the head lateral. Quite as good results can be secured, however, by the use of the canvas dam, which also can be used for turning water from field laterals. This dam consists of a large piece of canvas 6 to 10 feet square, one edge of which is fastened to a pole or iron rod sufficiently long to reach across the lateral and strong enough to support the canvas against the pressure of the water. Being light, the dam can be carried from one part of the field to another. It is inexpensive, and is made often of scrap material. An old wagon sheet or the carrier apron of an old binder or header will do for the canvas sheet and any strip of tough wood will do for the crosspiece. Under certain conditions a wrought-iron rod is preferable to the wooden crosspiece, for if it is desired to turn out only a portion of the stream, the rod may be bent downward and the remainder of the stream allowed to flow on.

The advantages and disadvantages of the flooding method may be summed up as follows: The principal advantages are: The cost of preparing the land is comparatively small, aside from the general turning up of the field's surface, there is no need of disturbing the surface soil; it readily adapts itself to the delivery of water in continuous flow. The principal disadvantages are: The amount of labor required to handle the water is large; one man can not thoroughly irrigate on an average more than 3 acres in 10 hours; in all grain crops the field ditches have to be renewed each spring; it may be difficult to distribute the water evenly over the surface.—(Ex. S. Circ. 67.)

Furrow Irrigation.—Nearly all crops that are planted in rows and cultivated are irrigated by means of furrows. This applies to such crops as potatoes, sugar beets, corn, vegetables, and fruit. The ground is first plowed, leveled, and graded in much the same way as that just described. The field is then divided so that each part can be readily watered from a head ditch. The distance between any two consecutive head ditches depends chiefly on the soil. In porous, sandy soils furrows should not be more than 300 feet long. In soils which absorb water less freely they may be 400 to

600 feet long. These head ditches are fed from the main supply ditch of the farm, and are usually made after the field is partially leveled and graded.

The presence of an impervious hardpan near the surface causes sidewide seepage of the water, a greater wetting of the surface and consequent increased loss by evaporation and by accumulation and run-off at the lower end of the furrows.

Shallow irrigation furrows do not give as good results as deep ones; they allow a large part of the water to rise by capillarity to the surface on either side and thence to escape into the air by evaporation, while deep furrows enable the soil to receive and retain nearly all of the water applied.—(Ex. S. Bul. 203.)

Division of Water Among the Furrows.—The chief trouble in furrow irrigation is to divide the water in the head ditch somewhat equally among a large number of furrows. The irrigator may wish to turn water into fifty furrows at the same time and, unless he uses some device other than a shovelful of dirt taken out of the ditch bank, the distribution will not be uniform. One of the best devices yet used for this purpose is a short pipe or spout, which may be made of wood. For small amounts of water less than 1 miner's inch, two pine laths cut in two and the four pieces nailed together in the form of a pipe answer very well. For larger streams, requiring from 1 to 6 miner's inches, half-inch boards of the required width are used in place of the half laths. A pipe is inserted in the lower bank of the head ditch opposite each furrow and placed 2 or 3 inches below the surface of the water. In some localities where water is scarce and valuable, flumes and pipes of various kinds are used to convey and distribute the water to furrows.—(F. B. 263.)

The main distributing laterals in the field should be placed 10 to 20 rods apart, depending upon the slope of the land and the nature of the soil, and may be given grades of one-half inch to an inch per rod. Each lateral should carry 2 to 3 cubic feet of water per second, as one man can usually handle this volume with ease after getting the stream set.

The advantages of this method are: The surface soil is not so apt to bake; a small head of water may be economically handled; there is less loss of water by evaporation than with flooding. The principal disadvantages are: The difficulty of maintaining an equal flow in all furrows; where the soil is not uniform in texture an even distribution is hard to secure; the upper end of the field is likely to receive more water than it requires; the furrows interfere with cutting and handling the crop.—(Ex. S. Circ. 67.)

The check method of irrigation is confined mainly to alfalfa. It consists in dividing up a field in contour, or rectangular checks, each comprising, as a rule, from one-half acre to 1½ acres. Around the margin of each check a low embankment or levee is formed which retains the water until it has been absorbed by the soil.

Laying Out the Field.—The field to be checked is first to be laid out in contour lines—lines connecting points of equal elevation—the difference in level between any two being from 3 to 6 inches or more, depending on the slope. With 3-inch contour on land which slopes 8 feet to the mile, the contour lines would be about 160 feet apart. On steeper slopes this space is decreased and the elevation between adjacent contours increased. Land which slopes 50 feet or more to the mile is not suited to check irrigation. The contours may be located by the use of an engineer's level and rod, or by a homemade level. When the contour lines are run the intervening spaces are subdivided into areas containing on an average about three-fourths acre. Provision is also made at this time for field ditches to convey water to each check. After temporary stakes are set to mark the corners of the checks a plow furrow is run around the margin of each so as to mark it permanently. In laying out these, contour lines are run and the rectangular checks are fitted into the spaces in such a way as to require the moving of the least possible volume of earth. Such checks cost more, but they are more convenient for farming operations.

Building Levees.—In building the levees around checks a scraper drawn by two to three horses or mules is generally used. All knolls and hummocks within the check are first scraped down and the earth placed in the levee. If more dirt is needed, the high corner or end of each check is removed, leaving the floor fairly level, or with a slight grade away from the check box where the water is admitted. The field is then plowed, harrowed, and seeded in the usual way. Levees when first built are too high and steep, but with the subsequent plowing, harrowing, and settling they should become satisfactory about the time the first crop of alfalfa is ready to cut.—(F. B. 263.)

The location of laterals will be governed by the character of the soil and the slope of the ground. On light soils a grade of 2 or 3 feet per mile should be the maximum. In general, the best results will be obtained if each check is supplied directly from a lateral, the lateral being made to form a portion of its boundary. In most cases such an arrangement is possible, and where the expense is not prohibitive this plan should be adopted. In cases where it is necessary to supply one check through another a broad, shallow depression across the check through which the water is to be carried will confine the flow of the stream and lead it to the check to be watered, without its spreading over the bottom of the higher check. If this depression be made 10 or 12 feet wide and 4 to 8 inches deep and given just enough slope to drain nicely toward the lower check gate, the crop will cover the sides and bottom of the channel and all implements will cross it without inconvenience.

No exact estimate can be given of the expense of checking, as the price will vary with the character of the land and also the locality. For contour checks the cost of building levees, leveling the checks, and constructing laterals averages about $7 or $8 per acre on ordinary land, including surveying at 20 to 30 cents per acre. Check boxes at $1 to $5 per acre would bring the total expense up to $8 to $13 per acre. In building rectangular checks on uniformly sloping land, one man with four horses and a scraper can check and level at the rate of 1 acre in two to two and one-half days. If the land be quite smooth one man can do this work at the rate of 1 acre a day. This would include the construction of laterals. In Oregon the cost of checking has been found to vary from $15 to $30 per acre for ordinary land.—(Ex. S. Circ. 67.)

Advantages.—(1) One irrigator can attend to a large volume of water, and can irrigate from 7 to 15 acres in ten hours, making the cost of applying the water less than by any other method; (2) certain soils can not be successfully irrigated by any other method; (3) it is well adapted to forage crops on flat slopes; (4) the cost of preparing the land for irrigation is small after the first year; (5) the amount applied can be more readily gauged.

Disadvantages.—(1) Much of the surface soil is removed to form the levees; (2) the yield is decreased where the top soil has been removed, except in deep alluvial soil; (3) mowers, reapers, and other implements are frequently damaged by high levees; (4) it is not well adapted to rotation of crops; 5) the method must be limited to particular crops and to flat slopes; (6) drainage for surplus water must be provided; (7) some soils bake after being flooded.—(Ex. S. Bul. 145.)

Summary of Cost of Irrigating for a Period of Five Years.

Period.	Requirements.	Average minimum cost per acre.	Average maximum cost per acre.
Flooding.			
First year	Grading the surface and building field ditches	$2.00	$5.00
	Irrigating three times	1.00	2.75
Second year	Repairing or making ditches and irrigating	1.20	3.00
Third year	......do	1.20	3:00
Fourth year	......do	1.20	3.00
Fifth year	......do	1.20	3.00
Average yearly cost		1.56	3.95
Furrow irrigation.			
First year	Building checks and laterals	1.00	10.00
	Irrigating three times	1.50	2.25
Second year	Making furrows and irrigating	2.00	2.75
Third year	......do	2.00	2.75
Fourth year	......do	2.00	2.75
Fifth year	......do	2.00	2.75
Average yearly cost		2.10	4.65
Check method.			
First year	Building checks and laterals	8.00	16.00
	Irrigating three times	.50	1.50
Second year	Repairing laterals and irrigating	.75	1.75
Third year	......do	.75	1.75
Fourth year	......do	.75	1.75
Fifth year	......do	.75	1.75
Average yearly cost		2.30	4.90

—(Ex. S. Cir. 67.)

Basin Method.—In all essential features the basin method does not differ from that just described. The fact that basins are used in the irrigation of orchards and checks in the irrigation of alfalfa, and the further fact that basins are much smaller and last but for one season, have served to distinguish between them and to accord to each a separate place.

Orchards are prepared for irrigation by this method by forming ridges of the loose earth midway between the rows of trees in both directions. These ridges are made with ordinary walking plows by throwing up two furrows or else by a ridger. When the top soil is light and free from weeds only the ridger is required, but in more compact soils and on soils covered with weeds the surface should first be disked.

Border Method.—One of the most common ways of fitting the surface to be flooded is to divide each field into narrow strips or "lands" by means of low, flat ridges of earth. These ridges extend from the head ditch at the upper margin of the field down the steepest slope to the bottom. When the slope is too steep they follow a diagonal course. In either case the field is divided into bands or borders, each of which is watered separately. The tract is first plowed or disked and then laid out in narrow parallel strips by plow furrows which mark the locations of the levees. On an average the levees are spaced about 50 feet apart and extend for a distance of 800 or more feet. They are usually formed with a scraper, which is driven back and forth in a direction at right angles to that of the markings, and as each full scraper crosses a marking it is dumped and the surface is again skimmed over to collect earth for the next levee. The ridges or levees thus formed are too steep and irregular and they are trimmed and flattened by suitable implements until their height is not more than 8 to 10 inches and the base is 6 to 7 feet wide. The land between the levees is carefully leveled and graded so as to permit water to flow in a thin sheet from the top to the bottom of each border.

Pipe Method.—Where water is pumped from wells and where it is conducted from gravity canals under pressure, a convenient way of irrigating certain crops is by means of surface pipes. These pipes are made at the factory into convenient lengths, usually 10 feet, of various diameters, and of different weights and kinds of metal. When not in use they are stored in an outbuilding or shed and carted to the field which is in need of water. In the main feed pipe, which is laid underground across the top of the field to be watered, there are standpipes at regular intervals, and a length of the movable pipe is attached to the lowest standpipe, using heavy canvas hose to make the connection. To this length others are attached until a line extends on one side of the field to within a short distance of the bottom. When the water is turned on, a section of canvas hose serves to distribute the water down the slope and as far on each side as the hose will reach. Several lengths of pipe are then removed and carried over to an adjoining strip. The hose is again attached and another block of land watered. In this manner an entire strip on one side of the field is watered, and the pipe is again strung out in such a way that the strip next to the first can be watered.—(Y. B. 1909.)

The preparation of land for irrigation with pipe and hose costs about the same as for open ditches and varies from $2.50 to $10 per acre, depending upon the conditions of the lands. While the expense of leveling a field is always money well spent, from the manner of application lands irrigated with pipes require less leveling than those to be irrigated by flooding from laterals. The cost of irrigating alfalfa with pipes and hose may be summed up as follows: With an average stream of 70 inches of water one man can irrigate from 1½ to 2 acres per day of ten hours, in addition to tending the pumping plant, where a gas engine is used. This area, of course, will vary with the nature of the land also with the stage of growth of the crop. The cost of labor for each irrigation, however, will not exceed $1.25 per acre, and should in most cases fall below $1. On the assumption that six irrigations are necessary during the dry season, the annual cost for labor should come inside of $7.50 per acre. When successfully grown alfalfa will yield from five to seven crops each year where it grows continuously, and each crop will yield from 1 to 2 tons per acre, according to local conditions. This gives an annual yield of from 7 to 12 tons per acre, which, at the current price of $8 and $9 per ton in the field, produces an annual gross return of from $56 to $108 per acre.—(Ex. S. Bul. 145.)

Reservoirs and Pumping.—In the older districts, where the stream flow in summer has been appropriated, a supply can often be obtained by building a storage reservoir or by installing a pumping plant. Small enterprises of this character may be undertaken by individuals, associations, or mutual companies.—(F. B. 263.)

Undoubtedly the most interesting and important phase of recent progress in irrigation practice is found in the use of the pump as a source of supply. Wonderful results have been achieved in increasing the efficiency of pumps and motors and reducing their cost of operation. Individual owners have often secured water by boring or digging wells and the use of a pump for much less than they could buy it from ditch companies and thus are enabled to use more water and at more convenient times with less outlay. For this home supply all sorts of wells and all kinds of pumps and motors are being used, according to local conditions of subterranean water-bearing strata and local power supplies. In irrigation by pumping several things should be borne in mind, viz.: That the capacity of all openings into underground water should be tested by pumping to determine what is the available supply; that, this being known, the motor and pump should be adapted to the supply by a competent expert and purchased under contract that they shall actually perform the service contemplated with the specified cost of fuel; that there is such great difference in efficiency and working cost between the modern pumping outfits and those of even a few years ago that one can not afford to accept an old-style outfit even as a gift; that makeshifts of discarded thrashing engines and second-hand pumps are too great an extravagance to be indulged in. These suggestions apply, of course, to all sources of pumped water, including wells, lakes, and streams.

The development of pumping from local sources of supply has not only made individual farmers independent of distant supplies, but it has led to the organization of many neighborhood co-operative undertakings which are proving very satisfactory, and has led also to traveling pumping plants, on wheels and on flat boats. All such undertakings seem to be satisfactory when they are up to date in machinery and methods.

On many farms there are already wells with windmills and pumps, for supplying water for stock, which can be utilized to raise a good garden of vegetables and small fruits, or to save a garden crop in a short season of drought. Either the mill is shut down much of the time or the water is allowed to waste onto the ground around the watering trough. The only added investment necessary in order to use this waste is for a tank or reservoir to hold the waste water until enough has accumulated to be of use. The water from an ordinary pump will flow but a few feet from the well if allowed to run on the ground, but if it is collected in a tank or reservoir, and run out in a good-sized stream, it can be carried for a considerable distance, even in an open ditch, and much farther in a pipe or trough, and can be made to water quite an area of garden.—(F. Buls. 263, 138.)

Winter Irrigation of Deciduous Fruits.—For a long time there existed considerable difference of opinion among fruit-growers as to whether, under the trying climatic conditions of the arid regions, the irrigation of an orchard during winter, when the trees were dormant, would materially lessen the amount of water that would need to be applied during the summer. That deep winter irrigation followed by thorough summer cultivation is better for deciduous orchards than the frequent application of small amounts of water during the growing season is shown by the following experiment:

In early winter water was applied about as rapidly as the soil would absorb it, until three feet in depth had been given the orchard. The last irrigation of the winter occurred in March. As soon as the soil was dry enough, the orchard was plowed each way about a foot deep, harrowed thoroughly and left for the summer. After summer showers, a cultivator was run over the surface to break up the crust that formed. In this way an earth mulch six to eight inches deep was maintained. No water was applied for over eight months, during which period the rainfall was but two and one-half inches, divided among five rains.

The trees remained in excellent condition throughout the summer. During May and June occurred the dryest hot period of which there is a record in southern Arizona. At the end of it the orchard showed no signs of drought, the peach trees having made a growth of about four feet, and the apricot trees a growth of three to six feet. During the dry, hot period mentioned above, the apricot trees matured a good crop of excellent fruit. Many of the peach trees remained unusually heavily loaded with fruit that matured during July and August, the quality being fully up to that of the previous year. Though having received no irrigating water for eight months, at the end of a season during which many orchards died, no thriftier or more vigorous orchard existed in the valley.

These results may be explained as follows: During the winter the lower temperatures and the higher relative humidity cause evaporation to be much slower than during the remainder of the year. In applying water, therefore, comparatively little escapes into the atmosphere. The supply of water being greatest at that time of the year makes it possible to apply large amounts at short intervals, thus avoiding the loss that occurs if small amounts are applied at greater intervals. Then, too, the trees are dormant and the roots need little air; hence, no injury is done them by keeping the soil supermoistened, or by letting the surface bake to some extent. Consequently, cultivation after each irrigation is not necessary, much time thus being saved.

During the summer the climatic conditions and the demands of the trees are quite the reverse of those of the winter. The high temperatures and the low relative humidity cause such rapid evaporation that much of the water applied quickly escapes into the atmosphere. The supply of water for irrigation being very low, it is not ordinarily possible to apply sufficient quantities of water to reach the deeply-seated roots of the tree. In summer a large percentage of the water applied escapes directly from the soil without passing through the trees. This is the case whether its surface is cultivated (as should be done) and the upper few inches loses all its moisture as a result; or the soil is left to bake (as should not be done) and not only the surface becomes dry and hard, but a large amount passes up from below through the baked soil.

If about the middle of the summer, water is available in abundance, it would probably be wise to give the orchard a thorough irrigation in as short a time as possible, and then follow the irrigation with a thorough plowing, as in the spring after the winter-irrigation ceases. But frequent summer irrigations are decidedly not advisable where the soil is fairly deep and retentive of moisture.

Irrigation Crops.—Tree planting should be one of the first things undertaken by the plains farmer, so that windbreaks may be established as soon as possible.—(B. P. I. Bul. 83.)

Alfalfa.—Alfalfa is most commonly irrigated by being flooded from field laterals. It is a tender plant for the first few months of its growth and requires favorable conditions. The feeding value of alfalfa is so high that the greatest profits can be obtained usually by feeding it to farm animals. When sold in the stack the net profits vary between somewhat wide limits. From the three tabulated statements which follow some idea may be given of the profits to the grower under skillful practice:

Profits from Alfalfa Growing.

Yakima Valley, Wash.:

Annual cost of water per acre	$ 1.50
Cleaning and repairing farm ditches	.50
Annual taxes	.75
Cost of applying water during the season	3.50

Cost of harvesting and marketing, 7 tons at $2	14.00	
Annual depreciation of hay tools, irrigation structures, etc	1.00	
		$21.25
Average yield of 7 tons, at $7		49.00
Annual profit per acre		27.75

Annual interest on investment 22.2 per cent, on a basis of land and water right valued at $125 per acre.

Parma and Roswell districts, Idaho:

Annual cost of water per acre	$ .50	
Cleaning and repairing farm ditches	.40	
Annual taxes	.60	
Cost of applying water during season	1.50	
Cost of harvesting and marketing 7 tons at $1.75	12.25	
Annual depreciation of hay tools, irrigation structures, etc	1.00	
		$16.25
Average yield of 7 tons at $5 per ton		35.00
Annual profit per acre		18.75

Annual interest on investment 18.75 per cent, based on land and water right valued at $100 per acre.

San Joaquin Valley, Cal.:

Annual cost of water per acre	$ 1.90	
Annual cost of applying water per acre	2.20	
Cleaning and repairing farm ditches	.50	
Annual taxes	1.00	
Cost of harvesting and marketing 7 tons at $2 per ton	14.00	
Annual depreciation of hay tools, irrigation structure, etc	1.00	
		$20.60
Average annual yield of 7 tons at $7 per ton		49.00
Annual profit per acre		28.40

Annual interest on investment 16.2 per cent, based on land and water right valued at $175 per acre.—(F. B. 373.)

Grain.—Grain fields are usually irrigated by flooding from field laterals. Furrow irrigation is practiced only where the soil bakes after being flooded. Grain is essentially a crop for the farmer with a very limited capital or for the farmer on new land. It is not advisable to grow many crops of grain in succession on new land, as the yields fall off rapidly. The land should be seeded to alfalfa, and grain used only in rotation after the first year or two. There is very little difference in the farm value of wheat, oats, and barley crops per acre, and for that reason the wheat crop is taken in estimating the gross and net returns per acre. The yield will average at least 40 bushels per acre and the price per bushel of wheat is taken at 75.1 cents.

The following statement is divided into four parts in order that the reader may more easily grasp the cost of different operations. It does not include any of the preliminary costs, as removing vegetation, leveling, etc.:

Cost of Growing Grain Per Acre.

Culture:		
Plowing	$2.00	
Harrowing and leveling	.90	
Seed	1.10	
Seeding	.50	
Ditching	.15	
Irrigating	1.25	
		$5.90
Harvesting:		
Cutting with binder	1.00	
Twine for binding	.50	
Shocking	.40	
Hauling	1.25	
Thrashing	2.50	
		5.65
Marketing:		
Hauling to local market or to cars		.75
Interest and taxes:		
Water tax	.50	
Tax on land	.30	
Interest on farm equipment	.25	
Interest on $100 at 8 per cent	8.00	
		9.05
Total		21.35
Gross returns:		
Forty bushels wheat at 75.1 cents per bushel		30.40
Net		9.05

Thus the above statement of cost and return gives a net profit of $9.05 per acre under favorable conditions, with average good farming.—(F. B. 399.)

Rice.—In 1909 the farmers of Louisiana, Texas, and Arkansas received over $18,000,000 for their irrigated rice crop. The well-drained, rich soil of that warm, humid region, when abundantly supplied with water at the proper time, is well adapted to the needs of this crop. Unlike most crops, rice must not only be flooded, but the top soil must be kept either continuously moist or submerged for a considerable part of the time.

Potatoes.—Potatoes and other root crops are irrigated by furrows made midway between the rows. These furrows should not be over 600 feet long, and in light sandy soils with little fall this distance should be reduced. Potatoes give good returns, both in yield and value. Thus, in South Dakota a yield of from 300 to 500 bushels per acre, ranging in value from 60 cents to 90 cents a bushel, has been reported.—(Ex. S. Bul. 210.)

Fruits.—The growing of fruit is profitable in many localities. An orchard in South Dakota 5 acres in extent, raised about 1,000 bushels of apples, besides pears, plums, and cherries. The net profits are stated to be over $1,000 per year, or $200 per acre. The trees are several years old and in full bearing.

Vegetables.—The raising of vegetables and small fruits is also a profitable industry. The yield is quite large, and the labor of cultivation is considerable, but the profits vary according to local conditions affecting the markets. The net returns range from $50 to $200 per acre.—(Ex. S. Bul. 210.)

Crop Returns.—The crop returns under irrigation in the semiarid region vary greatly with the crops grown. The returns as estimated in several states averaged as follows: Arkansas Valley in Kansas, $96.36 per acre per year; Platte Valley in Nebraska, $67 per acre per year; and on the plains in Eastern Colorado, $65 per acre. On one ranch the gross returns from 10 acres were estimated at $175, and the net returns, deducting the cost of raising the crop and interest on the cost of the reservoirs, $130, or $13 per acre. On another ranch the 35 acres irrigated gave a net return of $355, or more than $10 per acre. Another ranch on which were irrigated 175 acres of alfalfa and native hay shows net returns of $2,500—more than $14 per acre. It is apparent from these statements that irrigation in the semiarid region, in connection with dry farming or stock raising, is profitable.—(A. R. Ex. S. 1908.)

Quantities of Water Applied to Crops.—The quantities of water used on the leading crops of the arid region under field conditions have been measured in many places throughout the arid region, and the averages for the various crops in the different States and Territories are brought together in the following table:

Water Used on Different Crops.

State	Alfalfa.	Wheat.	Oats.	Barley.	Potatoes.	Sugar beets.
	Acre-feet.	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*	*Acre-feet*
Arizona		2.17		1.60	2.10	2.50
California	4.50					
Idaho	2.50	1.05	2.33	1.14		1.91
Colorado						2.40
Montana	1.15	1.43	1.74	1.41		1.46
Nevada	6.85	9.27			7.80	
Utah	2.97	1.48	1.37		1.17	2.24
Washington	3.11					
Wyoming			1.60		3.63	
Average	3.51	3.08	1.51	1.38	3.90	2.10
Average without Nevada	2.65	1.53			2.31	

A second average, excluding the Nevada measurements, is included in the table for the purpose of comparing the requirements of the crops. Much more water is used in Nevada than elsewhere, and the occurrence of Nevada measurements in some columns and not in others destroys the comparison. According to these averages the largest quantity of water is used on alfalfa, the other crops receiving water in the following order: Potatoes, sugar beets, wheat, oats, and barley. This is known to correspond with general practice. —(A. R. Ex. S. 1908.)

When to Irrigate.—How often to irrigate and how much water to apply must be decided by each individual in accordance with the character of his soil and the crop he wishes to produce. One experienced irrigator says: You can't irrigate by the clock. You must put water on when the crops need it and take it off when the want is supplied. Enough water is better than toc much. Two irrigations are usually sufficient for a crop of alfalfa or grass. Four or five are required for young orchards. Melons and beets should have no water for some time previous to maturity of the crop. Alfalfa, clover, and timothy should have no water during the maturing of the seed if seed is desired. Some foresight is required in using the water at your command, so that sections of the land may be irrigated consecutively for economy of both water and labor of applying it. Above all, watch your work. Do not start the water over a field and then go to town to spend the balance of the day. Each little stream requires attention.—(Ex. S. Bul. 145.)

Rotation of Crops.—The continued planting of any soil to the same crop will have the same effect on irrigated as on unirrigated land, the beet crop particularly being a heavy drain on soil fertility. Rotation, therefore, is an absolute necessity in maintaining the soil at its full productive capacity. Alfalfa, the principal crop throughout the irrigated areas of the West, is the plant most used in rotation. It not only fertilizes the soil by its nitrogen-absorbing properties, but is deep-rooted and yields good returns.

Two systems of rotation are usually employed. They are the six-year rotation and the eight-year rotation. In the first system the order is: Alfalfa, three years; potatoes or sugar beets, two years; and oats or wheat, one year. Alfalfa seed is sown usually with wheat or oats in the sixth year, and in the seventh year the ground grows alfalfa. In the eight-year rotation the order is: Alfalfa, three years; beets, one year; potatoes, one year; beets, one year; wheat, one year; oats, one year. Alfalfa is again sown with the oats.—(F. B. 392; Ex. S. Bul. 218.)

The advantages of farming under irrigation as compared with farming in a humid climate are:

(1) Better opportunities are given to properly prepare the seed bed, as the rainfall is seldom sufficient to make the soil so wet that it can not be properly worked into a good tilth.

(2) A dry surface promotes a better and deeper root growth and thus produces a much more vigorous plant.

(3) Water can be applied at a time that will produce the largest yields.

(4) The opportunities for harvesting without injury from rains are better.

(5) The yields of a first-class article are better.

Estimates of the cost per acre of farming under irrigation are given on the next page.

Cost Per Acre of Raising Various Crops.

WHEAT.

(Based on a yield of 40 bushels per acre.)

Plowing ground	$ 1.75
Preparation of seed bed	.75
Seed, 75 pounds, at 2 cents per pound	1.50
Seeding	.40
Irrigating	.60
Harvesting	1.00
Thrashing	1.75
Depreciation of machinery, etc	.50
Total	8.25

OATS OR BARLEY.

(Based on a yield of 60 bushels per acre.)

Plowing ground	1.75
Preparation of seed bed	.75
Seed, 75 pounds, at 2 cents per pound	1.50
Seeding	.40
Irrigating	.60
Harvesting	1.00
Thrashing	1.80
Depreciation of machinery, etc	.50
Total	8.30

BEETS.

(Based on a yield of 13.5 tons per acre.)

Plowing 8 inches deep	1.75
Preparing seed bed	1.50
Planting	.50
Seed, 20 pounds, at 15 cents per pound	3.00
Rolling	.25
Cultivating, four or five times	2.50
Bunching and thinning	7.00
Hoeing, two or three times	2.00
Plowing out beets	2.50
Three irrigations, at 60 cents each	1.80
Topping and piling	7.00
Siloing, 25 per cent of crop	1.20
Depreciation of machinery, etc	1.00
Hauling, not to exceed 3 miles	6.00
Total	38.00

—(Ex. S. Bul. 218.)

BEETS.

(Based on a yield of 12 tons per acre. Average price at all Colorado factories, $5 per ton.)

Plowing 12 inches deep	$ 3.00
Three harrowings and levelings	2.00
Seed, 20 pounds (\$2 to)	3.00

Planting	.40
Cultivating, five times	3.00
Rolling	.25
Bunching and thinning	7.00
Hoeing, twice	2.50
Three irrigations	1.80
Plowing out beets	2.50
Topping and piling	7.50
Siloing, one-fourth of crop	1.20
Hauling, within 3 miles	6.00
Depreciation of machinery, etc.	1.00
Total	41.15

POTATOES.

(Based on a yield of 150 sacks per acre. Average price for ten years has been 75 cents per 100 pounds.)

Preparing ground	$ 3.50
Seed, 1,000 pounds, at 75 cents per 100 pounds	7.50
Planting	.75
Irrigating	1.00
Cultivating, three times	2.25
Digging	7.50
Sacks	9.00
Total	31.50

POTATOES.

(Based on a yield of 100 sacks per acre. Average price for past ten years, 72.5 cents per 100 pounds.)

Plowing	$ 2.00
Harrowing	.50
Planting	1.50
Seed	9.00
Cultivating	1.50
Irrigating	1.50
Sacks	7.50
Harvesting	6.00
Marketing	4.00
Total	33.50

Water Charges.—The amount of water used rather than the number of acres irrigated is now established thoroughly as the wisest and best basis for charging for water. In co-operative or mutual companies such a question does not arise ordinarily, as stock ownership entitles an irrigator to his share of the supply run. Where water is sold to irrigators the question is an important one. Charging for the number of acres irrigated has proved wasteful both to consumers and irrigation companies and unjust to the careful irrigator by requiring him to pay the same amount for the water he uses as his slovenly neighbor pays for twice that amount. Paying for water actually received, and therefore at the same rate for water wasted as for water used, has been found not only to reduce the total amount consumed but also to benefit greatly the land irrigated. It also increases the areas possible to irrigate, benefiting both the individual irrigators and the public. Under practically all systems the charge amounts to one dollar per cubic foot per second for twenty-four hours.—(Ex. S. Bul. 229.)

Duty of Water.—By duty of water is meant the area or acreage of land which may be irrigated with a given quantity of water, as a cubic foot per second or miner's inch. Generally the duty of water is not high, that is, the area of land irrigated by a cubic foot per second is small. However, while this is and must always be a variable quantity, owing to variations in soils, conditions of use, different character of crops and other causes, the principal and most apparent reason for the low duty is the almost total lack of effort for economy in its use. The almost universal lack of knowledge among farmers of the measurement of water, and consequently of any effort to determine the quantity used, confuses and renders impracticable the determination of its duty. Ordinarily the duty of water is 100 and 200 acres per each "second foot," though it sometimes falls as low as 50 acres, and if water be very scarce or hard to secure it may reach as high as 500 acres per second foot.—(Univ. of Nev. Bul. 52; Tex. Bul. 43.)

Losses in Transmission.—Under present practice a very large part of the water diverted from streams for irrigation is lost by seepage from ditches, by evaporation from ditches and from the wet surfaces of irrigated fields, by percolation beyond the reach of plant roots, and by wasteful practice.

The limiting of the area irrigated is not the only bad result of losses and excessive use. The water wasted has swamped large areas once fertile, or brought up so much alkali as to injure or destroy vegetation, requiring drainage or the abandonment of the land.

A further disadvantage is the increased cost of irrigation due to building works large enough to divert and transport large quantities of water which not only serve no useful purpose but do positive harm.

A general statement of the total amount of loss of water must be made and accepted with reservation. It would appear that in the the main canals from 15 per cent to 40 per cent is lost, and in the laterals as much more. It would thus appear that not much over one-half, certainly not over two-thirds of the water taken from the stream, reaches the fields. In the most favorable aspect, the loss is great, and is relatively greatest when the loss can be least afforded, viz.: when the water is low and the ditches are running with reduced heads.

It is evident that these losses can be prevented by carrying the water in pipes, and very nearly stopped by lining canals with cement concrete or cement plaster, and as the magnitude of the losses is better appreciated and the value of water grows an increasing part of the water supply for irrigation will be carried in this way. But at present these means are too expensive for most places and most crops.

The real problem of reducing losses is to bring the cost within the limits allowed by the value of the water saved or to increase the net returns due to the saving by decreasing the cost still further.—(A. R. Ex. S. 1907; Col. Bul. 48.)

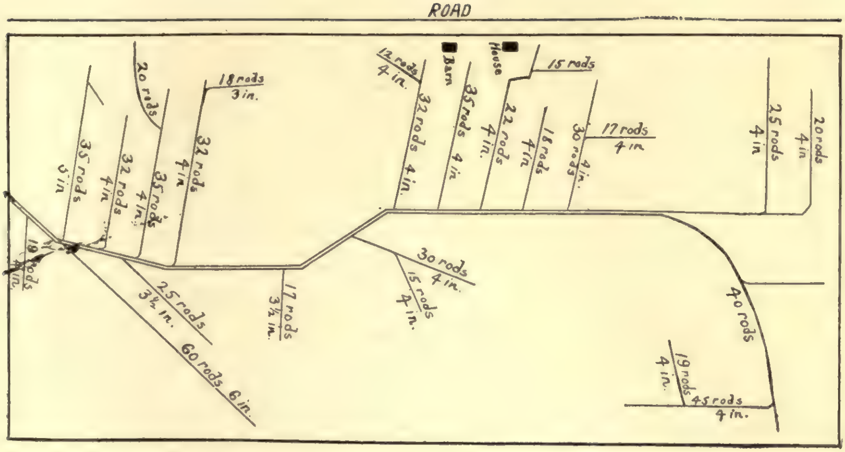
Co-operation.—Co-operative social development is a necessary feature of farm life in the arid regions. The first act of an irrigator usually is to associate himself with others for the purpose of constructing a ditch and appropriating water. Co-operation can not stop, however, with water development. It is equally necessary, by reason of distance from large populations, to associate for the purpose of marketing products. This co-operative spirit is favored by the intensiveness of the agriculture and the consequent smallness of the farms and the nearness of neighbors. Such communities, with interurban lines of travel, good roads, rural delivery of mail, and the numerous meetings necessitated by their canal, shipping, and other organizations, will necessarily attain a degree of social development far in advance of that possible to a country of large farms without the incentives to organization existing in an isolated irrigated region.—(Ex. S. Bul. 235.)

In addition, if the farmers on a lateral take turns in using the water, so that each may have a larger head of water, he need not use it so long. A company having determined the area to be watered by each lateral could turn into it the proportion of water to which it is entitled. The farmers could arrange before the beginning of the season the order and time in which each should have the use of the water, and then all plan their work to that end.—(Ex. S. Bul. 133.)

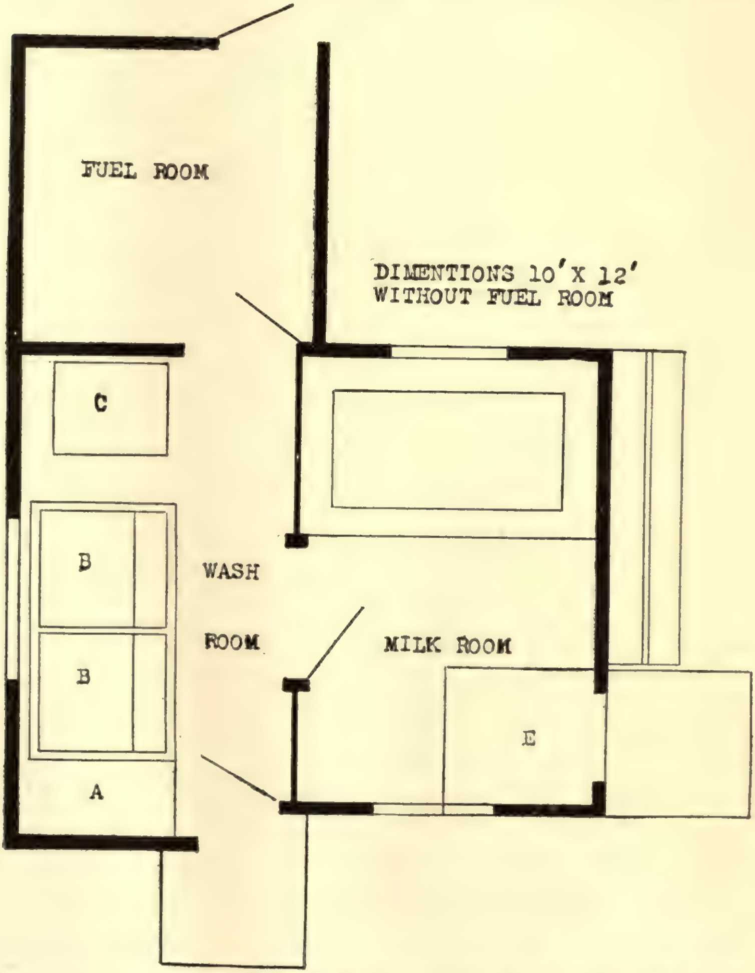
The essential feature of rotation is its economy. The greatest waste in irrigation comes from dribbling through farm laterals and over parched fields streams too small to accomplish much more than moistening the bare surface or equaling the rapid evaporation that occurs under usual field conditions. Heavy unavoidable losses attend attempts to supply all portions of an extensive system with water at the same time. The use of larger heads run for only a portion of the time in one section of the main canal or in one or two of the main laterals, to be run in the other sections or laterals later, does away with losses, lessens the time and the help necessary, and gives far better results to the farmers.

Rotation reduces evaporation and seepage losses in the main canals and laterals by increasing the head and the consequent rate of flow and economizes the time of the irrigators in applying water. It encourages care and promptness in application by the certainty that the supply will cease at a stated time whether or not the field is covered, eliminates the waste of a continuous flow when not in use, and aids greatly in the systematic use and delivery of water.—(A. R. Ex. S. 1907.)

Water Rights.—In a region of limited water supply a thorough understanding of the principles of law relating to the use of water is absolutely essential to harmony among irrigators and to the integrity of farm values. Associations have been organized in compliance with the principles of beneficial use of water on land; that particular



A System of Drainage. Dept. of Agr. (See pages 258-276.)



Floor Plan of a Small Dairy House Suitable for Dairy of 20 Cows. Dept. of Agr.

shares of water shall be appurtenant to specified areas of land; and that priority of appropriation gives the better right to the use of water, etc. They therefore provide for the enforcement of these necessary but hitherto much neglected features of the irrigation law. With a constant influx of settlers knowing nothing of the principles governing irrigation, sustained effort is needed on the part of the associations of irrigators, those called upon for legal advice, and educational institutions, to the end that all users of water may understand and observe willingly these indispensable equities in the use of water. That the adoption of irrigation generally will produce splendid results may be most confidently expected. Not only can crop yields be absolutely assured, but they can be greatly increased, in some cases doubled and trebled at an expense that is trifling when compared with the increased returns secured. Intensive farming is rapidly becoming the slogan of practical irrigators, and to the effective carrying out of this idea must be brought all the experience and scientific research of those who make a special study of the problems demanding solution.—(Ex. S. Bul. 226; Bul. 216.)

PART III

SOILS AND FERTILIZERS.

SOILS AND THEIR IMPROVEMENT.

WHAT the Farmer Should Know.—It is as important that the farmer should have a thorough knowledge of the characteristics of the soil of his farm as it is to know how to plant and to reap; to know his horses and his cattle, his machinery and the mechanism of his automobile. He should know the chemical qualities of his soil; its capacity to produce, to retain moisture, its absorbent qualities, and its heat transference. He should also know what elements of plant food each crop takes away from the soil.

Every practical farmer should know something of the mechanical characteristics of different types of soil, and particularly of those with which he has to deal on his own farm. If he can have made for him, by some competent person, mechanical analyses of the various types of soils with which he has become acquainted through practical experience and observation, he will be able to see the causes of some of the productive peculiarities of these soils that he has already observed but can not explain, and in many other ways the knowledge gained from these analyses will be of value. For a practical farmer to undertake to become an expert soil analyst is, however, a waste of time.

The first lesson the farmer should learn is that we have a great variety of soil types (700 having already been classified), and that each one of these types has its own peculiarities, its own characteristics, and its own special adaptation to crops, rotation schemes, and methods of soil control. This is the great fundamental fact which the farmer must understand. The first step in agricultural development is a knowledge of the particular soil characteristics of his farm.

The idea has prevailed in the past that through the use of commercial fertilizers and intelligent control all soils can be made to produce at will any crop that it is desired to grow. From a scientific standpoint this may be possible, but it can not be done at a profit. There are soils that can not be adopted commercially to wheat production, to fruit culture, and to any of the staple crops, and should remain as forest soils. The highest development of agricultural production will result from the adaptation of each type of soil to a particular line of crops, bearing in mind at all times the market requirements and the transportation facilities.

The work of the farmer and stock breeder in improving cultivated plants and domesticated animals is simply a continuation of the process of improvement carried on by nature before man existed, and for a long period after his advent, and before he had developed in the scale of intelligence to the point where he began to recognize the benefit to himself that would result from taking advantage of the forces of nature to shape animals and plants to his rapidly increasing needs and wants.

Individual farmers fail, and individual farms run down through neglect, lack of intelligent cultivation, and a lack of knowledge as to soil adaptation and methods of control. In many cases the cause of failure on the farm is due to individual neglect or mismanagement. This is a condition which can be improved, either through the force of necessity as has been the case in Europe, or through education. This is the age of science, but science means knowledge, and knowledge must be intelligently applied. Its intelligent application marks the difference between success and failure on the farm.

We may have light sufficient for a 200-bushel crop of corn, heat sufficient for a 200-bushel crop, and abundant rainfall for a 200-bushel crop, and yet the soil, the home of the plant, may be so hard and compact and impervious to plant roots, so non-absorbent and non-retentive of moisture as to limit the yield to 20 bushels an acre, even with good seed and abundance of plant food; or the soil may be in perfect physical condition, furnishing the plants an ideal lodging place, with light, heat, and moisture provided in abundance for a 200-bushel crop, and yet the supply of plant food, even of one element of plant food, may be so limited as to hold down the crop yield to 20 bushels an acre.

On some farms there are several different types of soil, and to be successful the farmer must make himself thoroughly acquainted with the special characteristics of each type. Such knowledge may make a great difference in the result of his farming. A farmer prepares his seed bed, plants his seed, carefully cultivates the plants, and gets no return. The failure is not owing to any neglect or care on his part, nor is it due to climatic conditions; but it is due to the fact that he failed to possess a knowledge of the characteristics of his soil.

The farmer should know the chemical and mechanical difference between light and heavy soils. The term light as applied to soils does not indicate that the soil is deficient in plant food, but that it is of such a texture as to be more easily worked than the soils known as heavy. Light soils are better adapted to the growing of some plants than to the growing of others. The farmer must know that soils of certain colors are better adapted to some crops than soils of another.—(Y. B. 1903, 1909; U. of Ill. B. 82; U. of Ill. B. 124; B. of Soils, B. 55.)

What Is Soil?—Soil is of three parts—one solid, another fluid, and the third gaseous. The solid part consists of mineral and organic matter in fragmentary or granular condition; it forms the stable body of the soil. The fluid part is a solution consisting of water carrying mineral and organic matter; it forms the circulatory medium of soil and plants. The gaseous part consists of air (nitrogen and oxygen) mixed with aqueous vapor, carbon dioxide, hydrogen dioxide, etc.; it permeates the body of the soil, moving with the movement of the circulatory fluid, changes in temperature and barometric pressure, etc. The three parts are conveniently known as soil body, soil fluid, and soil gas.

The soil of a country forms a unit or entity hardly less complete and distinct than the flora or the fauna. It differs from these in that it is suborganic rather than definitely organized, and in that it commonly contains a larger proportion of mineral matter; yet it resembles them in that it has its own modes of action and self-perpetuation, and in that it functions in accordance with its own special properties. Its internal action or functioning goes forward chiefly through the agency of its fluid and gaseous parts. In the absence of its circulatory medium it soon becomes inert or dead, losing its suborganic character; in the presence of soil fluid it is constantly vitalized.

We include in the soil all the material to the depth to which plant roots are able to distribute themselves. It therefore includes a wide range of material in depth and character. It may be deep or shallow, coarse or fine, loose or compact, light or dark, wet or dry. It is all soil because it is a medium for the growth of some kind of plant. In general, the soil may be divided into two classes of material: The particles of mineral and fragments of rock, and bits of organic matter of both plant and animal origin that have become more or less decomposed.

Practically all soils result from disintegrating rocks (muck and peat may perhaps be excepted). While the processes of disintegration are going on, vegetable matter is gradually accumulating in the decomposed materials, and as a final result there is formed the soil which is so familiar to us all.

Among the physical agencies which combine to effect the decomposition of the rocks may be mentioned heat and cold, water and wind, as well as the action of plants and animals. Chemical changes are also constantly taking place which aid very materially in breaking up the rocks. The oxidation of iron pyrites and the solution of limestone by carbonated waters are examples of these.

If, then, soil results from disintegrated rocks, it must partake of the nature of the underlying rock, unless some outside agency—such as moving ice—has disturbed the surface since the decomposition took place. However, on account of the long period during which the soil has been subjected to leaching, it will have lost much of some of the mineral compounds that existed in the parent rock.

It is apparent, then, that all the mineral elements that enter into a plant's composition must have come originally from the rocks. When the plant or animal ceases to exist as such and decays, then these elements are returned to the earth to be again taken up probably by other plants, or they may dissolve in the ground water and be carried out into the sea, perhaps to be taken up even there by plants or animals.

Soils are made up of small particles of different kinds of minerals mixed with more or less organic matter. These small mineral particles were originally formed by the breaking down of rocks through the agencies of weathering and decomposition. These include a variety of forces that do their work under different conditions but all produce the same ultimate effect, that of changing solid rock into fine material that may become the home of plants.

One of the most common physical agents is that of temperature, which does its work in two ways: (1) by the freezing of water contained in rocks and (2) by changes in temperature producing an increase or decrease in volume. All rocks contain more or less water, and when this water freezes it expands and exerts enormous pressure—about one ton to the square inch. This would be sufficient to shatter most rocks if frozen when the pore space was completely filled. As it is, the expanding water or ice breaks many rocks into pieces, and weakens others so that the repeated freezing is enabled to accomplish what a single freeze could not do. These small pieces are acted upon in the same way until they are reduced to material that will form soil.

It is common knowledge that a substance expands when heated and contracts when cooled. This change of temperature and consequent increase or decrease in volume takes place on the surface most readily, and the strain thus produced in rocks is sometimes sufficient to cause pieces to scale off, and even when this does not occur the rock is weakened so that other forces may do more effective work. When a sufficient amount of this fine material is formed for the growth of plants, especially shrubs and trees, the roots penetrate the crevices in rocks and by their growth pry off fragments, which are broken down by other agencies.

All rocks have more or less water passing through them, however slowly it may be. This water frequently dissolves out the more soluble material, which is often the substance that cements the crystals or particles of the rock together. This leaves it very loosely cemented, and other agencies soon reduce it to sand or other smaller particles. Rocks are made up of a number of minerals such as quartz, mica, feldspar, calcite, etc. Water containing oxygen and some other substances may have the power of decomposing or changing these minerals into other minerals. These may be more bulky than the first and tend to rupture the rock, or they may be softer and will be acted upon more rapidly by atmospheric agencies.

In some or all of these different ways rocks are broken down into particles of various sizes. These do not always remain where they are formed, but may be transported by wind or water and in their movement help to wear down solid rock or grind stones, gravel, or sand into still finer material. The wind aids in soil forming by driving the sand against hard surfaces, gradually wearing them away. The wind is also a distributing agent for soil material, picking up the fine dust and carrying it for some distance. In this way soils have been formed over large areas and others have been modified over still larger areas.

Running water is also a very important agent in the formation and distribution of soil material. During heavy showers more or less water runs off the surface and coarse or fine particles are moved, depending upon the volume and velocity of the moving water. Even on comparatively level areas some movement of soil material takes place, but it is in the ravines, gullies, and streams that the greatest amount of work is done by this agent. The volume and velocity of the water in many streams is sufficient to move all sizes of material, even to boulders weighing tons, and the crushing and grinding that goes on during the movement of these boulders, gravel, and sand is enormous. The finely ground up material as well as that washed in by streams is carried by the larger creeks and rivers and finally deposited, forming flood plains along their courses, or deltas at their mouths.

Glaciers have also been exceedingly important agents in the formation and distribution of soil material. While they are usually confined to arctic or mountainous regions, yet in times past, glaciers in the form of moving ice sheets hundreds of feet thick came down from the north, covering nearly all of the United States north of the Ohio and east of the Missouri Rivers, extending as far south as the Ozark Ridge. As this ice sheet advanced from the north, it picked up, pushed and carried along with it rocks of all sizes, shapes and kinds.

The grains of sand, silt, and clay contained in all soils consist of a large number of minerals, such as are also common to and make up the bulk of all common rocks, and, in addition, of very insoluble decomposition or alteration products. If a small sample of soil is thoroughly washed by decantation, being repeatedly pestled or violently shaken in a bottle with the water so as to loosen all the grains and wash out the fine material, or if it is merely acted upon by a dilute acid to remove the highly colored iron compounds, the variety of color and of form to be seen with the naked eye or with a hand lens will indicate the variety of mineral constituents. The common rock-forming and soil-forming minerals are—

Quartz.
Limonite—Turgite series.
Hematite.
Kaolin or kaolinite.
Feldspars.
Micas.
Apatite.
Hornblendes.
Pyroxenes.
Chlorites.
Tourmaline.
Rutile.
Calcite.
Dolomite.
Selenite.
Zeolites.

These minerals contain potash, phosphoric acid, lime, magnesia, and other mineral plant food.

Rain, wind, frost, glacial ice, streams, waves, plants and animals, and the solvent power of water, are at work continually on every exposed rock. By these agencies mountains have been reduced to plains, and lakes, and even oceans, filled to the condition of dry land. We may see these processes in operation by the roadside after a shower of rain, or in the garden, as well as in mountain parks. In the Alps Mountains, in Switzerland, the tops are capped by snow and ice which slide down the gorges with a tremendous grinding force; the ice melts and this great volume of water flows away with such violence as to furrow the rock slopes and carry away every bit of loose material. Trees and smaller plants pry their roots into the fissures, and winds send blasts of sand and dust against the ledges. Thus by degrees the mountain of rock becomes a plain of soil.

One may see these results wherever he is, and may observe the processes that have given rise to them. They may differ in magnitude but not in kind. Note how frost breaks up clods of clay and even of stone; how the rivulets after a rain gully the hillside and leave a mass of gravel or mud where the water comes to rest. Then note the plants that spring up, and observe their roots—how they thread their way about through the spaces in rock and soil, expanding each a little by their growth and search for water and food.

Soils are undoubtedly formed from the disintegration and decomposition of rocks, but rocks may also be formed from the consolidation of soils. These may again break apart into soils and be again reconsolidated into rocks. The most important fact in this connection is that all of our common rocks contain practically all of our common rock-forming minerals, though in widely varying proportions. One has but to look at a specimen of common sandstone or shale to see the plates of mica and other forms of minerals associated with the quartz. We find the same minerals in the sandstones, limestones, and shales as in the granite, gneisses, and schists. The differences, aside from variations in the relative proportions, appear to be that one set is formed by water deposition with or without pressure under ordinary temperatures, while the other set is formed under conditions of high degrees of pressure and temperature. There are of course exceptions in the case of any pure sandstone as there are in the case of exceptionally pure forms of igneous rocks. There is a question among geologists whether what we consider the oldest crystalline rocks in the United States have not in fact been formed by consolidation under great pressure and high temperature from assorted material worked over from still older and more primitive rocks.

It is a mistake to suppose that sandstones always give rise to sandy soils. Some of the most tenacious clay soils come from sandstone, as, for instance, the Penn clay from the Triassic red sandstone rock.

One of the most potent factors in the formation of all residual soils is the process of leaching. Thus, from the leaching of disintegrated rock have soils been formed. Limestone soils were originally impure limestone rock from which a very large percentage of the original rock material has been removed by leaching. No geological fact is better established or more universally recognized.

From 75 to 90 per cent of the original rock formation is not infrequently removed by leaching in the making of residual soils.

The best natural soils are those of which the materials have been derived from different strata, which have been minutely divided by air and water and are intimately blended together; and in improving soils artificially the farmer can not do better than imitate the processes of nature. The materials for the purpose are seldom far distant; coarse sand is often found immediately on chalk, and beds of sand and gravel are common below clay. The labor of improving the texture or construction of the soil is repaid by a great permanent advantage; less manure is required, and its fertility insured. The capital laid out in this way secures forever the productiveness and consequently the value of the land.

As a result of the many processes at work we have two general classes of soil. One results from the gradual disintegration and decay of rocks. Such soils, because they have not been moved from where first formed, are called sedentary soils. The famous limestone soil of Kentucky is of this class. The other class has been moved more or less, and is called transplanted soil. Water, wind and ice have been the chief means of transportation.

If a soil is examined closely it will be found to contain organic matter (fragments of plants), some of which can still be recognized readily as of vegetable origin, while most of it has decomposed to such an extent that it has lost its vegetable structure and original chemical composition.

Most soils have two natural divisions as to depth; the top-soil and the subsoil. The top-soil varies in depth with the soil types, usually being from six inches to twenty inches deep. It is frequently a little coarser in physical composition than the subsoil, because the finer particles are carried away by running water, and as the water percolates downward through the soil, these finer particles have a tendency to move down with it, and some finer material is carried down into the subsoil. The color of the top-soil varies with the type, but depends largely upon the amount of organic matter, or iron, or both. The organic is the more common and gives to soils a black or brown color. Iron compounds usually give a reddish color very much like iron rust. The top-soil is divided into the surface soil and the sub-surface soil. The surface soil extends as deep as the ground is plowed. This is the soil the farmer knows most about. This is the part that requires the most careful management, as it is the most important part of the soil in development of plant food, in germination of seeds, and in growth of crops, since it is largely concerned in absorption and retention of moisture, aeration, and temperature. It is commonly the darker part of the soil, because of its larger organic matter content.

The subsurface soil lies between the surface soil and the subsoil, or between the plow line and the subsoil line, where the change of physical composition, texture, or color indicates the beginning of the subsoil. In physical composition it differs but little from the surface soil except that it contains somewhat less organic matter;

this constituent diminishing with depth. The color of the subsurface soil is often very similar to that of the surface. It varies with the type, but depends primarily upon the amount of organic matter and iron present. There are some places where the top soil is only 6 or 8 inches deep, and rests directly upon the subsoil. In such cases there is no subsurface stratum, as the plow line and the subsoil line coincide.

The subsoil extends usually from 18 or 20 inches to unknown depths. The color is usually yellow, and the subsoil is frequently spoken of as clay, although it commonly contains much more silt than clay. The physical composition of the subsoil is frequently different from the top soil in that it contains more of the finer soil particles that have been carried downwards from the soil above by percolating water. It generally contains only a small amount of organic matter. The character of the subsoil is of very great importance, for upon that, to a large degree, depends the drought-resisting power of the soil. If the subsoil is coarse sand or gravel the water will pass through it and cannot be drawn back by capillarity and so is lost to the crop, which will suffer from drought in consequence. If, however, the subsoil is silty or clayey, a large amount of water will be retained in it and much of what passes to lower depths will be brought up within reach of the roots by capillarity. Subsoils sometimes contain a layer of impervious material such as compact clay, carbonate of lime, or oxide of iron, which is commonly called hardpan. This is very objectionable if within three feet of the surface, since it prevents the upward and downward movement of water and the deep penetration of plant roots. The crops on level hardpan land suffer from much rain because the water cannot get down through this to drain away, and they suffer from drought because the water below this layer cannot be brought up through it by capillarity.—(Bu. of Soils, B. 55; Fla. Ex. Sta. B. 93; Colo. Col. B. 65; Y. B. 1897; Cornell R. C. Soil Series 1; Ill. Col. B. 82, 124; Bu. of Soils B. 22.)

Organic Matter in Soils.—Less is known about the nature of the organic constituents than about the mineral constituents of the soil. All kinds of animal and plant remains and their decomposition products are liable to occur in the soil. The great problems of chemistry of the soil will probably be found in a study of its organic constituents.

The color of a soil is not a sure indication of the amount of organic matter which it contains. Some characteristically black soils have less organic matter than some of the red or yellow soils. This appears to be a question of the condition of the organic matter, resulting from different processes of decay. In some soils it breaks down into a black product, the kind of material which we recognize by the undefined term humus. In other soils the material is of a much more neutral tint or even colorless. Such soils usually yield, however, an intensely black solution when extracted with a dilute alkali, especially on standing in contact with the air.

A high degree of lasting fertility is usually associated with black soils, and they are usually considered more productive than yellow, red, or brown soils, but many notable exceptions to this rule are known. The trouble often experienced in obtaining satisfactory crops on newly reclaimed swamp land and fresh muck suggests itself as an example; also the high productive capacity of the brown or red soils of the Hagerstown series of central Pennsylvania and the Indian red soils of the Penn series in New Jersey. The density of black, as also the shade of color of the mineral matter of the soil, will often indicate to a trained observer differences in soils which mark decided differences in crop adaptation.

Every good soil contains organic matter. The most famous soils, such as those of the Genesee bottoms, the prairies of the Northwest, or the valley of the Nile River, are well stocked with the decayed remains of plants and animals, which generally impart a dark or black color. The presence of much organic matter greatly increases the productivity of any soil. The experienced farmer usually identifies a dark colored soil as a fertile one for this reason.

Organic matter in this partially decomposed and darkened condition is commonly known as humus, and is the same kind of material as that which leaches from swamp and manure heaps in the form of a brown liquid. This partially decayed plant and animal material is the most valuable single constituent of the soil and the one which every good farmer strives to save and augment. It helps to keep the soil loose and friable, improves its drainage, makes it warmer than it would be otherwise, helps to hold water in a form available for crops, and renders more available the store of food which every soil contains. The maintenance of humus is accomplished by leaving as much of the crop as possible (stubble and roots) on the soil, by turning under green crops occasionally, and by the addition of manures from the stable or the factory. Without the maintenance of humus a permanently productive system of husbandry cannot be maintained.

This vegetable material is derived from various parts of plants, as roots, stems and leaves, and has been incorporated in the soil by various agencies. The roots of some grasses and some plants penetrate the soil to a depth of from ten inches to twenty inches, and decaying become an agency in the formation of the soil. Good, productive soils should contain from five per cent to ten per cent of organic matter.—(Bu. of Soils, B. 55; Ill. Col. B. 82; Cornell R. C. Soils Series 1.)

Absorption.—A very important property of solids in contact with liquids which tends to control the concentrations of soil solutions and to prevent undue waste of material is the power the soil grains have of absorbing and holding on to dissolved salts. This absorptive power varies greatly with different soils and with different minerals, and varies for different substances or parts of substances. It is stronger for potash than it is for chlorine, and a weak solution of potassium chloride passed slowly through a soil comes through acid with hydrochloric acid, the soil having retained more of the potash than of the chlorine. If some silver nitrate is passed slowly through finely divided charcoal, the salt is decomposed by this selective absorption, some free nitric acid comes through, and small spangles of silver can be seen in the charcoal.

On account of this absorbing power it is altogether unlikely that fertilizers applied to soils in ordinary amounts will noticeably increase the concentration of free water in the soil. The material for these minerals may come from great distances or from great depths, as a result of the slow but profound movement of ground waters. They form a very important part of the soil fertility.

Every one knows how important it is to have a plentiful supply of moisture for the growing crop, but few realize the value of organic matter in maintaining the supply in time of drought. The organic matter acts as a sponge. Its effects upon moisture content are evident in two ways, (1) in the increased storage capacity and absorbent power for water, and (2) in preventing evaporation by its retentive power and by allowing a more perfect surface mulch than could otherwise be formed. Sand permits of rapid percolation with comparatively small amounts of water retained. If different amounts of organic matter are added to the sand, the quantity of water retained increases with the increase of organic matter.

Besides this holding back of nutrient soluble salts, the absorptive power of a soil has an important part in determining its physical condition. There is a relation between the quantity of soluble salts absorbed by the soil and the size and compactness of the soil-grain aggregates; and upon the size and arrangement of these soils aggregates, in turn, the optimum water content of the soil depends. The openness of a soil determines its ventilation, and thus likewise its opportunity for securing proper oxidation and for the forming of humus. The optimum water content as determined by plant growth coincides in general with the percentage of moisture at which the soil has its maximum volume, and at this maximum the soil also shows its greatest openness or minimum resistance to root penetration. Likewise, through its absorptive power the soil removes from soil solution and soil atmosphere the waste products thrown off by growing roots, which products are detrimental or inhibitory to continued growth.

The absorption of nutrient salts by the soil not only maintains a proper soil solution, but also exercises a marked influence upon the size of the soil aggregates. This soil structure in turn governs the water-holding power, the porosity, and consequently the aeration of the soil; and these factors are of the utmost importance to the bacterial life in the soil, as well as to the changes in the organic and mineral constituents.—(Bu. Soils B. 32, 51, 52, 55.)

Texture of Soils.—The texture of the soil is determined by the proportion of the different sized mineral particles it contains. The texture determines to a large extent the relative power of soils to hold water. Under equal conditions of depth and exposure coarse-grained soils hold less moisture and more air than fine-grained soils, so that taken as a whole they contain less solution, and consequently a smaller quantity of nutrient material in solution. They also have generally a lower absorptive capacity and presumably permit a much more rapid and at times possibly an excessive oxidation.

When, aside from texture, the physical and chemical properties of the soil and its method of formation are alike, we have what is called a soil series, extending from the coarse gravelly or sandy soils on the one side to the finer silt and clay soils on the other, and in such a series the texture of the soil determines the distribution of crops. In some soils the mineral particles have a grandular arrangement of flocculated masses, making the soil loose and porous. In others the grains appear to have no such coherency, but exist in a compact form, making the soil hard and compact. We also have the gumbo and adobe soils and others that are exceedingly plastic. Then, again, the amount and character of the organic matter influences not only the productive capacity of the soil, but its adaptation to crops, while the color of the soil has to be considered as indicative of certain obscure chemical or physical relations that influence the adaptation and productivity.

Other things being equal, as the texture varies the water-holding capacity of the soil will also vary, the light sandy members of the series or the sandy types holding on the average not over 4 per cent of water, while the clay members at the other end of the series will hold 20 per cent of moisture. With this difference in moisture there is a corresponding difference in the soil atmosphere and oxidation is usually much more rapid in the sandy members than in the clay members of a series.

Color as Indicating Fertility.—In the past too little attention has been given to what appears to be the influence of color, or some associated properties of the soil which determines the color, on the yield and qualities of the crop.

Careful observation has shown that the black, red, yellow, blue, and white soils of the Coastal Plains are essentially different in their properties and in their relation to the yield and quality of crops. The soil man knows that on the red soils of the Orangeburg series, whether the Orangeburg sandy loam, the Orangeburg loam, or the Orangeburg clay, he will get a tobacco from Cuban seed which has a certain texture and a certain aromatic quality which can not be obtained from the same seed planted on the yellow soils of the Norfolk series, in adjoining fields, and under identical climate conditions. The texture of the soil in this case will influence the texture of the leaf. On the light soils of the Orangeburg series he will know that the product will be a thinner leaf and that on the heavier soils of the same series the leaf will be heavier and contain more gum, but will have the same aromatic qualities. On the yellow soils of the Norfolk series in the South Atlantic and Gulf States he will get the finest quality of wrapper leaf of the Sumatra type, without aroma, with little gum, but with an elastic texture and a bright glossy finish which can not be equaled on the red Orangeburg soils. Why the color of the soil should indicate this is not apparent. It does not seem probable that it is due to the actual difference in color or even to the differences in oxidation and hydration of the minerals which occasion the color, but to some property in the soil which determines that under similar climatic conditions the color of the one soil derived from the same material of the Piedmont Plateau, laid down under similar conditions, shall consistently be red, while the soil of an adjoining field may be yellow. The chemical properties exhibited in the differences in color of these two soils, it is believed, have an effect upon the chemical changes influential on the quality of the crop.

That color is to a considerable degree indicative of productiveness is shown also by the change which takes place in the subsoil between the time when it is freshly turned up and when brought into a condition favorable for crops. In the Atlantic Coast States, particularly, it is not uncommon to find subsoils deleterious to crops if too much of the material is turned up at any one time by the plow, and it is interesting to watch a skillful gardener improve a piece of raw land of such character. He adds a little manure and spades it in lightly, and still the soil is not in first-class condition for a crop. He lets this lie four or five weeks and respades and finds the color gradually and slowly changing. It may take three or four years to produce a fertile soil out of the raw piece of land or out of a subsoil in this way, and his experienced eye can tell from the color changes the rate of progress with which the change is taking place. The gardener knows that by his methods of soil fermentation and by the increased oxidation brought about by intelligent methods of handling certain changes have taken place in what was formerly the raw subsoil to fit the material for crop production. In this case it is not the lack of organic matter, for this can be supplied at once, but it is the form or the condition of the organic matter in the subsoil which indicates to him unfavorable conditions for plant growth, and these conditions he ameliorates or changes both by the addition of organic manures and by judicious cultivation.

The soil expert knows what can be accomplished by these artificial means, but he knows that no means are available to produce the Cuban tobacco of high aroma on the yellow soils of the Norfolk series or the Sumatra type of wrapper leaf of equally high quality on the red soils of the Orangeburg series. He also knows from experience that with the highest art of cultivation the black soils of the Portsmouth series will produce different crops—or the same crops of different quality—than will the black soils of the Houston series.

In the glacial regions the black soils of the Marshall series and the yellow soils of the Miami series are another striking example of differences in crop adaptation indicated by color differences. The greater productiveness of the darker soils is not dependent upon the amount of organic matter, because two soils may have the same amount of organic matter and yet have entirely different crop values, but it is due to differences in the condition of the organic matter.

The red soils of the Orangeburg series of the Coastal Plains are stronger and more lasting under hard usage than the adjacent yellow soils of the Norfolk series. The former will produce more cotton and will stand more continuous culture with the same good treatment. In Alabama and Texas they will produce a cigar-filler leaf of fine aroma, while the Norfolk soils will produce a finer grade of Sumatra-wrapper leaf without aroma.

The yellow Norfolk soils and black Portsmouth soils are very different in their crop production. The former are adapted to early potatoes, peas, radishes, lettuce, and the lighter spring vegetables; the latter to cabbages and the heavier truck crops. Organic matter added to the Norfolk soils darkens them very little, but when added to the Portsmouth soils makes them still blacker, indicating a difference in the process of decay or in the final stable form of organic matter in the two soils, and affecting in some way their adaptation to crops. Whether this difference in the chemical changes in these soils is associated in any way with the forces which determine the form of the iron compounds in the Norfolk and Orangeburg soils referred to is unknown.

Instances of this kind, where slight differences in shade in the red, yellow, or black soils are associated with differences in yield or quality of crop, at least in certain seasons and under certain conditions of temperature and rainfall, could be multiplied indefinitely.—(Bu. of Soils, B. 55; Cornell R. C. Soils, Series 1; Univ. Ill. B. 82; B. of L. B. 79.)

SPECIAL CHARACTER OF OUR SOILS.

For convenience in survey and description the Bureau of Soils of the Agricultural Department has divided the country into a number of soil districts or provinces.

Atlantic and Gulf Coastal Plains.—The Atlantic and Gulf Coastal Plains together constitute one of the most important physiographic divisions of the United States. The Atlantic Coastal Plain extends from the New England States southward to the Florida Peninsula, where the Gulf Coastal Plain begins, and extends thence westward to the Mexican boundary line. It is, however, discontinuous, being interrupted by the alluvial bottoms of the Mississippi River. From the coast the Atlantic Plain extends inland to the margin of the Piedmont Plateau—that is, to a line passing through Trenton, Baltimore, Washington, Richmond, Raleigh, Columbia, Augusta, and Macon. In its northern extension it is represented by a narrow belt, but widens in New Jersey and attains its maximum breadth of about 200 miles in North Carolina. The Gulf Plain extends up the Mississippi to the mouth of the Ohio, its inner boundary line passing through or near Montgomery, Iuka, Cairo, Little Rock, Texarkana, Austin, and San Antonio.

The surface is that of a more or less dissected plain marked by few hills, slightly terraced with bluffs along streams. The inner margin of the Coastal Plain is usually from 200 to 300 feet above tidewater, but sometimes rises to 500 feet. The drainage here is usually well established and the surface is rolling to hilly, and consequently carved and eroded. There is a wide belt bordering the coast where the elevations are mostly under 100 feet. North of the James River, where the Coastal Plain is narrow and deeply indented with tidal estuaries, drainage is usually well established and the surface is rolling, but in the broad southern extension, where the seaward slope is hardly more than 1 foot to the mile, drainage is apt to be deficient. Here rain water often remains upon the surface for a considerable time, although the conditions are not comparable with those of a true swamp. The soils in this level section, while composed largely of sand, are compact, usually deficient in organic matter, and not very productive. Many of the flat interstream areas possess such poor drainage that true swamps, such as the Dismal and Okefenokee, have been formed. Near the coast and along the tidal estuaries extensive marshes, separated from the ocean by sand barriers, are found.

The Coastal Plain is made up of unconsolidated gravels, sands, and sandy clays, with less frequent beds of silts and heavy clays. The deposits on the Atlantic coast have been derived mainly from the erosion of the Piedmont Plateau and other inland areas, while the deposits on the Gulf coast have been derived mainly from transported glacial material and from western plains. The materials have been transported and deposited beneath the sea and subsequently exposed by the uplift of the ocean floor. In the more northern parts of the Coastal Plain, and even as far south as Virginia, the character of the deposits has been modified by glacial action and the flooded condition of the streams resulting from the melting of the ice.

The Coastal Plain deposits range in age from Cretaceous to Recent. Although extensive areas of the older sediment are exposed at the surface to form soils, still by far the greater part of the materials is Quarternary or Recent in age.

The soils are for the most part composed of sands and light sandy loams, with occasional deposits of silts and heavy clays. The heavy clays are found principally near the inner margin of the Coastal Plain. The silts, silty clays, and black calcareous soils, upon which the rice and sugar cane industries of southern Louisiana and Texas are being so extensively developed, have no equivalents in the Atlantic division.

Bastrop Series.—This embraces four types of soil—sandy loam, fine sandy loam, silt loam, and clay. They are brown in color, and are found only in Texas. Cotton, corn, sorghum, alfalfa, melons and potatoes are successfully cultivated.

Crockett Series.—This, also found in Texas alone, comprises four types—gravelly loam, fine sandy loam, loam, and clay loam. The soil is gray to dark gray, sometimes almost black in color. The clay loam yields cotton above the average, and is used for general farming purposes; the gravelly loam is adapted to early vegetables and trucking.

Elkton Series.—This consisting of sandy loam, fine sandy loam, loam and silt loam, is of a light gray to white. Some types of this series are found in Delaware, Maryland, New Jersey, Pennsylvania and Virginia. The series is best suited to grass and forage crops.

Gadsden Series.—This is composed of three types—sand, sandy loam and loam. The soils are found in Florida, Georgia and Mississippi. The sand is very productive, and of special use in growing

Florida Sumatra wrapper tobacco; the sandy loam is good for cotton, sugar cane and corn.

Houston Series.—This occurs principally in the black, calcareous prairie regions of Alabama, Mississippi, and Texas. The soils are characterized by a large percentage of lime, especially in the subsoil, which in some of the types consists of white, chalky limestone. The series has been derived from the weathering of calcareous clays, chalk beds, and rotten limestones, all of late Cretaceous age. In some localities remnants of later sandy and gravelly deposits have been mingled with the calcareous material, giving rise to the gravelly and loam members of the series.

The soils of the Houston series constitute the fertile black prairies of the Gulf States, and are not found east of Alabama. They are without question the most productive upland soils of the Gulf Coastal Plain, a fact mainly due to their calcareous nature. The Houston black clay, locally known as black waxy land, is the most extensively developed soil of the series. In the sections where it occurs it is the best cotton soil. In the past it has been used chiefly in the production of this crop, but, being well adapted to alfalfa, in recent years the acreage in this legume has steadily increased. In its virgin state it supported a heavy growth of native prairie grasses and in some sections hay and pasturage are still its important products. The Houston clay, while not as valuable land as the black clay, has a special adaptation for alfalfa, and produces good yields of cotton and the other staple crops. In the vicinity of San Antonio, Tex., there is associated with the Houston black clay a black clay loam soil that is good cotton, corn, and sorghum land, and which, under irrigation, could be profitably used for some truck crops.

Laredo Series.—This consists of gray to light-brown calcareous soils with gray calcareous subsoils. They occur as a terrace along streams in south Texas and also constitute the principal soils of the Rio Grande delta above overflow. They are made up largely of material which has been brought down from the calcareous and more arid parts of the State. They are seldom or never overflowed, and constitute very valuable farming lands when irrigated.

Laredo Silty Clay Loam.—This is a very productive soil and well adapted to growing early vegetables. Profitable yields of corn, cotton, and sugar cane are obtained. Fair yields of both cotton and corn are often secured in a favorable season without irrigation. Lettuce, melons, cauliflower, beets, peas, cabbage, onions, eggplant, cucumbers, tomatoes, carrots, and both sweet and Irish potatoes are all profitably grown under irrigation. Cabbage is the principal crop and the average yield is about 18,000 pounds per acre; the average yield of onions is about the same. Irish potatoes yield from 60 to 70 bushels and sugar cane 25 to 30 tons per acre. The clay loam, also recognized in the Laredo area, is well adapted to the production of onions, giving an average yield of about 20,000 pounds per acre. Alfalfa has been grown under irrigation, though the stand continues good for only one year. Cabbage, beets, and Irish potatoes do well. Sorghum, cowpeas, and sweet potatoes give good returns. The Laredo silty clay

Object Lesson Road at Bucklin, Kansas. Dept. of Agr.
(See pages 149-165.)

Section of Road with Sand-Oil. Dept. of Agr.

A Road in Arkansas Systematically Dragged with a Split-Log Drag.
Dept. of Agr.

is found in the Brownsville area. Some alkali areas are found in this soil, but yield readily to treatment. When well drained and put under irrigation good yields of corn, cotton, sugar cane, lettuce, cauliflower, tomatoes, beans, peas, cabbage, and other vegetables are produced. The silt loam type of soil gives the best returns under irrigation. It is well adapted to onions, which give an average yield of 18,000 to 20,000 pounds per acre. Cotton has been grown under irrigation and where irrigated sweet potatoes produce 150 to 200 bushels per acre. Some corn has been grown on the irrigated land, as have cabbages, beets, turnips, and Irish potatoes. Cabbage yields about 13,000 pounds to the acre. Cowpeas do well on both the unirrigated and irrigated soils.

Lufkin Series.—This is found in Alabama, Louisiana, Mississippi and Texas, is a gray surface soil, and heavy. It is not very productive, but is believed to be well adapted to truck crops and to peaches.

Montrose Series.—This is found in the south central part of Mississippi, extending into Alabama; is gray in color and not well adapted for agriculture.

Norfolk Series.—This consists of light colored sandy soil and comprises the most important truck soils of the Coastal Plain, the different soils not only being specially adapted to special kinds of crops, but also having a wide general distribution from New York to Texas. Of this series the fine sand taken all in all is the leading soil for general trucking. In earliness it lies between the coarser soils on the one hand and the finer on the other. It is less leachy and droughty than the Norfolk sand or coarse sand, and is more easily kept in a productive state. Besides the lighter truck crops, it is a valuable soil in Florida for the production of a fine grade of Sumatra wrapper tobacco, and in North Carolina and Virginia for cigarette tobacco and peanuts. In Maryland it is the best soil for the French type of tobacco. In trucking areas large acreages are devoted to strawberry culture. In the sea islands of South Carolina it is the principal soil upon which the long-staple cotton industry has been developed.

Of the coarser types of the series the gravel and gravelly loam are not extensively developed and are not at present of much agricultural value. The coarse sand and coarse sandy loam are in the same category, but the Norfolk sand, which is a type of wide distribution, is an important soil because of its extreme earliness, and a consequent special use in the forcing of light truck crops for the very early market. It is a leachy and droughty soil and requires heavy manuring and fertilizing to produce profitable yields. Asparagus has proved a most profitable crop on this soil in North Carolina, and watermelons are grown with success in Georgia, extra early potatoes and lettuce in Virginia. These crops indicate special uses of the Norfolk sand, but there are many others that do equally as well in one or another part of its wide occurrence. A special adaptation in the sea islands is long-staple cotton.

The fine sandy loam is not so valuable for early truck as the fine sand, but is an excellent medium to late truck soil and in some sections it is known as cabbage land. In North Carolina it is esteemed a better cigarette-tobacco soil than the sandy loam and fully equal to the fine sand. It is better for general farming than the lighter soils of the series, and is used extensively in the production of cotton, being the best of the Norfolk series of soils for growing this crop. In certain parts of Maryland it is a fine general purpose soil, giving good yields of wheat, corn, and hay in addition to heavy truck and fruit, principally peaches.

With a larger acreage than any of the other soils of the Norfolk series, the sandy loam is an important resource of the Coastal Plain. It is used for Irish and sweet potatoes, bright yellow tobacco, cotton, peanuts, and heavy truck crops and fruit. In Maryland some areas are considered the best general farming lands.

The loam and silt loam are suited to diversified agriculture, the latter being rather the better soil. In New Jersey and Eastern Shore of Maryland good yields of wheat, corn, and hay are secured, and some dairying is practiced. The soil is used for the same general farm crops around Norfolk and in addition Irish and sweet potatoes are grown to some extent. The clay is apparently most extensively developed in Alabama. In many cases it needs drainage, and with good cultivation produces good yields of cotton and corn.

Portsmouth Series.—This is characterized by dark gray to black surface soils. In different types it is found in Delaware, Florida, Georgia, Kentucky, Maryland, Mississippi, North and South Carolina and Virginia. The various types are mostly used for truck crops.

Orangeburg Series.—This is gray and brown in color and is found in the Gulf Coast States. The soils of the Orangeburg series are somewhat stronger than the corresponding types of the Norfolk series. They are used for about the same crops. The Orangeburg sand is a fine truck soil, and in Florida is used for growing Sumatra wrapper tobacco under shade. It has characteristics that suggest its adaptation to peach culture. The fine sand is an easily worked soil under a wide range of moisture conditions. It also has a wide crop adaptation, being used for truck, fruit, and the staples—corn and cotton. It is especially adapted to peaches and plums. The sandy loam is likewise adapted both to general farm crops and truck. In Orangeburg County, S. C., it is considered the best general farming soil, and is also used for bright-yellow tobacco, though some of the Norfolk soils give a better quality of leaf. In Florida, Alabama, and Texas it produces a high-grade cigar wrapper and filler leaf. The coarse sandy loam has a rather low agricultural value. With the most extensive development of any of the soils of this series, the fine sandy loam is a very important Coastal Plain soil. Cotton, corn, tobacco (both the bright-yellow cigarette in South Carolina and the Cuban filler cigar types in Alabama and Texas), fruit, and truck are grown. In the Fort Valley section of Georgia it is the principal peach soil, and in east Texas this crop is also an important one. Strawberries and other small fruits thrive. Cotton is the chief crop upon the Orangeburg clay, which is typically the best general farming soil of the series. Grain and forage crops do well upon it and stock raising or dairying are industries that might be introduced. This clay often has a veneering of sandy loam, and in such cases is used to advantage for truck and small fruit. The two types, gravelly sandy loam and loam, have so far been found in limited areas. The latter is an excellent soil for cotton and the staple general farming crops.

Sassafras Series.—This consists of yellowish-brown surface soils found in some parts of Maryland. The sand and loamy sand are light, well-drained, naturally warm, early soils especially adapted to truck crops like garden peas, asparagus, early Irish potatoes, strawberries, and dewberries. The sandy loam is widely distributed and is a good soil for general farming. It is considered the best tomato soil of the Eastern Shore. Strawberries, potatoes, asparagus, peaches, pears, dewberries, and other small fruit make excellent yields. The crop adaptations and agricultural value of the fine sandy loam are nearly the same as for the sandy loam. It is, however, better suited to grass than the latter type. The loam is probably the best all-round general farming soil of the north coastal plain and gives fine yields of wheat, corn, hay, tomatoes, and other medium truck crops. The type is easily managed and its productiveness easily maintained if sufficient organic matter is supplied and moisture conditions kept favorable. The silt loam is also an excellent soil best suited to general farming. It is not particularly well adapted to truck crops, although tomatoes, cabbages, and some other vegetables do fairly well. The gravelly loam is easily tilled and is an excellent soil for orchard fruits like peaches, plums, and pears, and is also a fair corn soil.

There are a number of other soil series and types in the Atlantic Gulf Coastal division, but they are limited in areas and are of small productivity.

RIVER FLOOD PLAINS.

An extensive and characteristic group of soils, usually known as bottom lands, is found in the flood plains of numerous rivers and streams of the United States. The largest development of this group occurs along the Mississippi River, where the bottoms are often many miles in width.

The soils have been formed by deposition from stream waters during periods of overflow. The texture of the material depends upon the velocity of the current at the time of the deposition. Where the current is very rapid, large stones and bowlders are borne along and beds of gravel and sand are formed. Along the swift-flowing streams the texture of the soil changes often within short distances, but in wide bottoms large areas of very uniform soils are often formed. The soil material has usually been derived from various kinds of rocks, but in some instances is closely related to the surrounding geological formation. The red soils along the Red and other rivers in the Southwest have been formed by the reworking of the Permian Red Beds. In general, the soils along the streams which flow through the prairie region have a darker color than those along the streams which run only through the timbered sections of the country.

The difference in the origin, drainage, color, and organic matter content has given rise to several series of alluvial soils in the humid portion of the United States.

Congaree Series.—Brown or reddish-brown soils found along Piedmont streams and representing wash from Cecil soils. Valuable and dependable corn soils, but too low and moist for cotton.

Huntington Series.—Dark-brown to yellowish-brown soils occurring along streams in the Allegheny plateaus. Both the general farm crops and truck crops thrive on these soils.

Miller Series.—Soils of the Miller series are among the most productive alluvial soils of the United States. The Miller fine sand gives moderate yields of cotton and corn, and higher lying areas seem adapted to fruit, especially peaches. Vegetables also do well. The fine sandy loam, a more extensive member of the series, gives better yields of cotton and corn, and is also well adapted to truck and fruit, peaches, plums, and pears being grown to considerable extent in parts of Texas. It is also an excellent soil for alfalfa, the acreage of which has been rapidly extended in recent years. Vegetables may be grown with profit, and in some cases irrigation is practiced, the water being secured from artesian wells. The silt loam has about the same extent as the fine sand. It is used for about the same crops as the fine sandy loam and clay, i. e., cotton, corn, sugar cane, and alfalfa. The clay is the most extensive and strongest soil of the series. Surpassed by few soils in the production of cotton and alfalfa, it is no less valuable in the growing of sugar cane. The Miller soils from their origin and the relatively circumscribed area of the formation from which they are derived are not an extensive series.

Ocklocknee Series.—This is gray to yellowish-brown soils found along streams, in Coastal Plain Alabama, Georgia and Mississippi. Cotton, corn and pasturage are the leading products.

Wabash Series.—This comprises the most important of the alluvial types of soil. It embraces those soils having a dark-brown to black color and a large percentage of organic matter. These soils are typical of the Mississippi River, but there is no sharp distinction between them and other bottom soils found along the rivers of the Middle West. The Wabash soils are among the strongest and most productive types of the country.

The most extensive type of the series is the silt loam, by far the greater part of which is found north of the southern tier of States, and therefore cotton is not so important a crop as corn, grass, and small grains, of which fair to large yields are secured, depending upon the condition of drainage. The next soil in point of area is the Wabash clay. In the Southern States this is considered the best cotton soil, producing on the average over a bale of lint to the acre. Farther north it gives large yields of corn. A small area of the heavy clay has been found in Texas, where it gives heavy yields of cotton, corn, oats, and forage crops. The Wabash loam is the third soil in area; occurring to the north of the cotton sections it is used chiefly for corn, to which it is well adapted. It can be used to advantage in the production of canning crops, such as sugar corn, tomatoes, green peas, and beans. The fine sandy loam is of limited extent. Some areas produce heavy yields of wheat, oats, corn, while others are better suited to melons, sugar beets, Irish potatoes, and alfalfa. The principal crop on the sandy loam is corn. It is also suited to truck crops. The heavier silt loam and clay loam are both valuable soils, though as yet only small areas have been encountered in the soil survey. Heavy yields of grass, corn, alfalfa, Kafir corn, sorghum, and moderate yields of small grains are obtained.

Waverly Series.—This is composed of light colored alluvial soils subject to overflow. Less productive than the Wabash soils, this series is adapted to the same wide range of crops.

Wheeling Series.—These brown to yellowish-brown soils occur on gravel terraces, along streams issuing from glacial regions. Excellent soils for general farming purposes and fruit and truck growing.

PIEDMONT PLATEAU.

Lying between the Atlantic Coastal Plain and the Appalachian Mountains and extending from the Hudson River to east central Alabama is an area of gently rolling to hilly country known as the Piedmont Plateau. On the Atlantic side it is closely defined by the "fall line," which separates it from the Coastal Plain, but on the northwestern side the boundary is not so sharp, although in the main distinct. In its northern extension the Piedmont Plateau is quite narrow, but broadens toward the south, attaining its greatest width in North Carolina.

The surface features are those of a broad, rolling plain that has been deeply cut by an intricate system of small streams whose valley walls are rounded and covered with soil, although many small gorges and rocky areas occur. The altitude varies from 300 feet to more than 1,000 feet above sea level.

The extreme northern part of the Piedmont region, in New Jersey, has been glaciated, but elsewhere the soils are purely residual in origin and have been derived almost exclusively from the weathering of igneous and metamorphic rocks. The chief exception is the detached areas of sandstones and shales of Triassic age. Marked differences in the character of the rock and the method of formation has given rise to a number of soil types, those derived from crystalline rocks being the most numerous and widely distributed. Among these the soils of the Cecil and Chester series predominate. The principal types formed from the sandstones and shales are included in the Penn series.

Cecil Series.—This includes the most important and widely distributed soils of the Piedmont Plateau. The heavier members are known as the red-clay lands and are characterized by red clay subsoils, with gray to red soils ranging in texture from sand to clay, the lighter colors prevailing with the sandy members.

The soils of the Cecil series produce general farm crops throughout their extent and in the South cotton is the important crop. Both heavy export and bright tobacco are generally grown, the character of the leaf produced depending on the depth and texture of the soil.

The clay is the typical soil of the Piedmont Plateau and occupies two-fifths of the total area of the series. It is recognized as the strongest soil for general farming. It is adapted to grass, wheat, and corn in Maryland and Pennsylvania, and export tobacco, wheat, and grass in Virginia, cotton, with corn and wheat secondary, in the Carolinas and Georgia. Cowpeas succeed on this soil perhaps as well as anywhere in the country. The sandy loam, while not as strong a soil as the clay, is generally preferred by the farmers on account of greater ease of cultivation. It is the lightest soil of the series suitable for general agriculture. In the South cotton is the leading crop, with corn next in importance. In Virginia and the Carolinas it is used both for bright-yellow and dark-shipping tobacco. Besides these staples a great variety of minor crops is produced. Next in extent is the Cecil sand, which is generally recognized as the bright tobacco soil of the Piedmont region. It is especially adapted to sweet potatoes and watermelons. The silt loam and loam are types of moderate productiveness and are used in the production of corn, cotton, wheat, oats, and tobacco. The fine sandy loam is used chiefly for corn and cotton. It produces fine-textured tobacco, and is also suited to the growing of peaches and plums. The stony loam is found mainly in the more northern States, where it is a good general farming and apple soil. The clay is an excellent corn soil and produces fair crops of wheat, oats, and hay. So far this soil has been found only in Pennsylvania.

Chester Series.—This series occurs in the northern part of the Piedmont, having been found only in Pennsylvania, Maryland, and Virginia. This series differs from the Cecil series in having yellow or only slightly reddish subsoils and gray or brown surface soils, which are on the whole lighter and more friable than those of the Cecil series. The members of this series are also much more micaceous and even more subject to erosion than the soils of the Cecil series. Locally they are known as gray lands to distinguish them from the red lands of the Cecil series. The topography in general is not so rough, being rolling to moderately hilly.

Chester Series.—The soils of this series occur with the Cecil series in Pennsylvania, Maryland and Virginia. They are gray to red soils. They are not so strong as the Cecil soils, and require more careful handling to maintain the yields. While used mainly for general farming and especially adapted to corn, it is also well adapted for fruit growing. In Maryland it is used for canning crops; sweet corn and tomatoes occupying important positions.

Penn Series.—This series consists of Indian or purplish-red soils. It is especially adapted to grass and grain, and is well suited to dairying.

APPALACHIAN MOUNTAINS AND PLATEAU.

The Appalachian Mountains are made up of a number of parallel ranges and intervening valleys, which extend in a general northeast and southwest direction from southern New York to northern Alabama. The elevation ranges from about 1,500 to nearly 7,000 feet above sea level, the highest point being attained in western North Carolina.

Immediately west of the Appalachian Mountains and usually separated from them by a valley is a wide stretch of country known as the Allegheny Plateau. In a broad way this plateau is carved out of a great block of sedimentary rocks tilted to the northwest from the mountains. It is crossed by numerous streams. As they run in deep channels (all the larger ones being from 200 to 1,000 feet in depth) the dissection of the plateau block is often minute.

The rocks of the eastern ranges of the Appalachian Mountains are igneous or metamorphic in origin, while the western ranges, as well as the Allegheny Plateau, are made up of sedimentary rocks. Different series of soils have, therefore, been formed in different parts of these mountains and plateau. The igneous and metamorphic rocks give rise to the soils of the Porter series, while the Dekalb and Upshur series are formed from the weathering of the sandstones and shales of sedimentary origin.

The character of the topography in the mountain and much of the plateau region is such that general farming is not practicable. These areas are, however, well suited to grazing and fruit growing, and these are very important industries.

Dekalb Series.—Brown to yellow soils with yellow subsoils, derived from sandstones and shales. Soils of this series are used, according to texture, elevation, exposure, and character of surface, either for the production of hay, for pasture, or for orchard and small fruits.

Fayetteville Series.—Grayish-brown to brown soils with yellowish or reddish-brown subsoils. Adapted to apples, grapes, and small fruits, and give moderate yields of general farm crops.

Porters Series.—Gray to red soils with red clay subsoils, derived from igneous and metamorphic rocks. This is the greatest mountain fruit series of the eastern United States. It is also used for general farming.

Upshur Series.—Brown to red soils with red subsoils, derived from sandstones and shales. Somewhat more productive than the Dekalb soils. Used for cotton, corn, wheat, and forage crops.

LIMESTONE VALLEYS AND UPLANDS.

The limestone soils are among the most extensively developed of any in the United States and occur in both broad upland and inclosed narrow valley areas. The greatest upland development is seen upon the Cumberland Plateau in eastern Tennessee and Kentucky and upon the Carboniferous formation in central Tennessee and Kentucky, northern Alabama and Georgia, and in Missouri. The valley soils are found principally in Pennsylvania, Maryland, and Virginia, and in the mountain section of eastern Tennessee and Kentucky and northern Alabama and Georgia. The topography of the plateau soils varies considerably. In the Cumberland Plateau and Highland Rim the surface is undulating; in the region of the Ozark uplift in Missouri and Arkansas it is quite rough and hilly, and where there is an elevation of the surface, or where the plateau is deeply dissected by erosion, it presents a quite mountainous topography. The valley soils of the Appalachian region also show considerable topographic relief, sometimes exhibiting mountainous surface features.

The limestone soils are residual in origin, being derived from the weathering in place of limestone of differing age and composition. This is accomplished by the removal through solution of the calcium carbonate of the limestone, leaving behind the more resistant siliceous minerals. These soils are remarkable for the fact that they contain but a very small percentage of the original limestone rock, the larger part having gone into solution. It has thus required the solution of many feet of rock to form a single foot of soil.

Clarksville Series.—Light-gray to brown soils with yellow to red subsoils, derived mainly from the St. Louis limestone. While not as strong as the Hagerstown soils, this is a valuable series. Apples and peaches are commercially important. Tobacco is a leading product. General farming is firmly established in many extensive regions.

Cumberland Series.—Brown surface soils, derived from thin deposit of sedimentary material overlying residual limestone subsoils. Used for cotton and other general farm crops, truck, and fruit.

Decatur Series.—Reddish-brown to red soils with intensely red subsoils. Intermediate in value between the two series just described. Cotton, corn, wheat, oats, forage crops, bluegrass, and peaches are the leading crops.

Hagerstown Series.—Brown to yellowish soils with yellow to reddish subsoils, derived from massive limestone. Among the most productive soils of the eastern United States. Fine wheat and general farming soils, and the seat of important apple orcharding interests. Bluegrass is indigenous.

GLACIAL AND LOESSIAL REGIONS.

The soils of the glaciated part of the country constitute one of the most important groups in the United States. This group includes all soils derived directly from till or loess. The soils formed from the till are confined to that part of the country lying north of the southern limit of glacial action, but the loess soils occur also south of this line, especially along the Mississippi and Ohio rivers and in Kansas and Nebraska. The line of the southern extension of the ice sheet touches the Atlantic coast about New York City, passes through northern New Jersey, southern New York, and northwestern Pennsylvania, swings southwestward through Ohio to Cincinnati, crosses the Mississippi River at St. Louis, and follows the south side of the Missouri River into Montana, where it crosses the Canadian boundary line, then dips southward into Idaho as a long lobe in the mountainous nonagricultural region, and crosses the northwestern part of Washington, including the Puget Sound region.

Practically all of the United States north of this line was covered in recent geological time by a great continental glacier, many hundreds, and even thousands, of feet in thickness. This great ice sheet, moving in a southern direction, filled up valleys, planed off the tops of hills and mountains, ground up the underlying rocks, carried the derived material both within and upon the ice, and finally deposited the gravel, sand, silt, and clay as a mantle, varying in thickness from a few feet to more than 300 feet. Often this material has been transported hundreds of miles, and is wholly unrelated to the underlying rocks, but in some places the movement has been slight, and the drift consists very largely of the ground-up underlying rock. Over a large proportion of the area covered by the drift and also along the Ohio and Mississippi rivers and in Kansas and Nebraska the surface material consists of a fine silty deposit, known geologically as loess and plains marl. In the classification of the glacial soils three important series—Miami, Marshall, and Volusia—having distinct characteristics have been recognized, and, in addition, quite a number of miscellaneous soils which can not be put in any series.

Marshall Series.—This includes the dark colored upland glacial and loessial soils which cover almost all of the great prairie region of the central West. They are of a dark brown color. The topography is level to rolling. These soils are very productive and constitute the great corn soils of the country. The Marshall silt loam, loam, and clay loam constitute the principal soil types throughout the great corn belt and rank among the most productive of our general farming soils. In Iowa, Illinois, and Nebraska corn, oats, clover, and timothy are the leading crops, while in Minnesota and the Dakotas wheat is of primary importance.

Miami Series.—This is one of the most important, widely distributed, and complete soil series that has been established. The series is characterized by the light color of the surface soils, by derivation from glacial material, and by being timbered either now or originally. The heavier members of the series are better adapted to wheat than the corresponding members of the Marshall series, but they do not produce as large yields of corn.

The clay loam is the most important for general farming, and forms the principal type of soil in western Ohio and central and eastern Indiana. It is especially well adapted to small grain and grass crops. The silt loam is more rolling and hilly than the clay loam and is not so well-suited to general farming. Wheat does better upon it than upon the Marshall silt loam, with which it is closely associated, but the yields of corn are considerably less. It is also well adapted to fruit, especially apples. The sandy loam and fine sandy loam are used for general agriculture, but are especially adapted to medium and late truck crops and fruit. The loam is suited to corn and potatoes, while small grain and grass are grown, but with less success than upon the clay loam. Strawberries and raspberries, as well as other small fruits, do well on this type. The stony sand, gravelly sand, and gravel are not of much agricultural value under present conditions. The stony loam is a good general farming soil, is also well adapted to apples, and furnishes excellent pasture, while in New York alfalfa is grown upon it very successfully. The stony sandy loam and gravelly sandy loam are not strong soils, but are fairly well suited to light farming, fruit, and truck. The sand and fine sand are not adapted to general farming, but are the best early truck soils of this section.

Volusia Loam and Silt Loam.—These are the most important types of the series. The surface of the loam is less rolling than that of the silt loam. The former is well adapted to the production of potatoes, grass, oats, buckwheat, and corn in less elevated portions. Apples are also grown to advantage throughout a considerable part of its extent. The silt loam occupies rolling and hilly land and is frequently interrupted or bordered by steep slopes not suited to agricultural purposes. Where properly cultivated it is a good soil for timothy and small grain. Owing to the hilly character of the country, transportation by wagon is rather difficult, and the type should be used more for the raising of cattle and sheep, in order to utilize its known capabilities for the production of hay and oats, rather than for the growing of bulky grain products which must be hauled to market at considerable cost. The stony loam is rather above the average of the other members of the series for general farming. On well-drained areas, particularly on northern and northwestern slopes, apple orchards are highly successful. The gravelly loam and clay loam, while only of very limited occurrence, are good soils, the former being particularly adapted to apples and the latter to grasses. There are large areas of these soils which are not as highly developed as they should be or as they have been in the past.

GLACIAL LAKE AND RIVER TERRACES.

Another important group of soils occurs in the glacial region, principally as terraces around lakes, or along streams, or as deposits in areas which were formerly covered by water. At the close of the Glacial epoch the lakes in this part of the United States were not only more numerous, but the waters of those which remain reached a higher level and covered areas that are now far above their present shorelines. In some cases several distinct terraces, each one marked by an old shoreline, are easily discernible, and represent successive stages in the lowering of the water level. Their elevation above the lake varies from a few feet to more than 200 feet. The surface of each terrace is usually rolling to level, with a gradual slope toward the lake, but sometimes areas of a rough and broken character occur. The streams which cross these terraces have frequently by their cutting produced deep, steep-sided valleys, especially near the lakes.

The soils of this group vary from typical beach gravels to offshore deposits of heavy clays. The material from which they are derived consists of glacial debris reworked and redeposited in the lakes or along streams. While this glacial material is made up of rocks of widely varying origin, a large proportion of it often consists of the country rock. In the eastern part of the Great Lake region the percentage of sandstone and shale fragments is usually very high, while in the western part more of the igneous rocks are present. This fact, together with differences in drainage conditions, has given rise to several series of soils.

Clyde Series.—The soils of the Clyde series consist of reworked glacial material containing a large percentage of organic matter. The surface soil of this series is of a dark-brown to black color, underlain by gray, drab, or mottled yellow subsoils. The dark color of the surface soil, which is the most distinctive characteristic of this series, is due to the accumulation of a large percentage of organic matter under swampy conditions. The soils of the Clyde series may be considered as intermediate between the light-colored Dunkirk soils on the one hand and the Muck and Peat areas on the other. They almost always require drainage, and when this is provided they are very productive.

The loam is the most important member of the series, both in extent and in agricultural value. In Michigan it constitutes the most highly prized soil for sugar beets, giving the most uniform and satisfactory results. When well drained it gives excellent yields of corn, wheat, oats, and hay. Cabbage and canning crops also prove profitable.

Dunkirk Series.—The loam is a very important member of the Dunkirk series. It is a good general-purpose soil and is considered fine for fruit, especially apples, pears, plums, and cherries. The color, flavor, and keeping quality of the former two are better than upon either the lighter or heavier soils. The silt loam is easily tilled and produces good yields of general farm crops, besides berries and fruits. Upon the clay loam, clay, and stony clay wheat and grass do well while near the Lakes grapes are grown with much success. The sandy loam and fine sandy loam are quite extensively used for trucking and small fruits. They are a little light in texture for general farming. Peaches on the fine sandy loam produce a strong, thrifty tree and a good flavored fruit. Grapes are also successfully grown. The fine sand is not suited to general farming, but for early truck and other crops requiring a light sandy soil it has proved valuable. Peaches, apples, and pears are grown, but the trees are usually short lived and subject to disease, while the fruit is of inferior quality. The gravel is of little value except for the production of grapes. The gravelly sandy loam gives moderate yields of ordinary farm crops and should be used as a fruit, potato, and corn soil. The gravelly loam gives large crops of corn and fair crops of hay and oats, while potatoes, beans, and pears also do well.

Fargo Series.—This series occurs throughout the Red River Valley and in other old glacial lake beds in the same region. They are very black in color and contain a very large percentage of organic matter, in some cases enough to make the soil slightly mucky. The clay loam is the most extensive and one of the strongest types of soil in the Red River Valley. The silt loam is probably the most desirable here and is well suited to wheat, oats, barley and flax.

Hudson Series.—This series consists of light brown to yellowish-brown soils. It is well adapted to truck and small fruits and produces fair yields of general farm crops.

Merrimac Series.—Brown terrace soils underlain by gravel formed principally of reworked glaciated crystalline rocks. Leachy soils of low general farming value, but especially adapted to trucking and apple orcharding in some sections.

Sioux Series.—Dark-colored soils resting on dark or light-colored subsoils, with gravel beds usually within 3 feet of the surface. The crops produced on soils of this series range from early short-seasoned truck crops through special crops like alfalfa and sugar beets to the wide variety of general farm crops produced in the Central West.

Superior Series.—Gray and red soils with red subsoils, formed from reworked glacial material deposited in glacial lakes. Not extensively developed, but known to include fine types for clover, timothy, and small fruits.

Vergennes Series.—Light-colored soils, with gray or whitish subsoils, derived from Champlain clays or lighter deposits over these clays. This series includes the best hay and apple soils of the Champlain Valley. A wide variety of tillage crops is grown, but cultivation of the heavier members of the series is very difficult.

RESIDUAL SOILS OF THE WESTERN PRAIRIE REGION.

This region consists of the nonglacial part of the prairie plains bounded on the north by the Missouri River, the southern limit of glaciers, and extending southward through Texas to the Rio Grande. On the west it merges into the Plateau region at very near the 2,000-foot contour, and on the east is limited by the Gulf Coastal Plain and the Ozark Plateau. Its surface is gently rolling, with occasional low hills, and is cut by numerous stream channels. The rocks are of Carboniferous age and consist of sandstones, shales, and limestones more or less interbedded. These rocks give rise to three series of soils, viz., Oswego, Crawford, and Vernon, together with a number of miscellaneous soils. In Kansas and Texas these soils are in some instances more or less modified by the admixture of gravel and sand from Tertiary deposits brought down from the higher areas farther west occupied by crystalline rocks.

Crawford Series.—Brown soils with reddish subsoils, derived from limestones. The soils of this series range from rough areas suited mainly for pastures to fertile general-farming, fruit-growing, and trucking soils.

Oswego Series.—Gray or brown soils, derived from sandstones and shales. The lighter members of this series are adapted to corn, oats, potatoes, truck, and fruit; the heavier to these crops and wheat.

Vernon Series.—Brown to red soils typical of the Permian formation. Soils of this series show a wide adaptation according to texture. General farm crops, including cotton, corn, wheat, Kafir corn, and sorghum are the leading products. Small fruit, peaches, and truck are grown to some extent and are capable of marked extension.

GREAT BASIN.

With the exception of one soil type recognized in the Laramie area, Wyoming, the soils in this group are confined to the Great Interior Basin region. They are derived from a great variety of rocks, and consist of colluvial soil of the mountain slopes, deep lacustrine and shore deposits of the Bonneville period, and of recent stream-valley sediments and river-delta deposits.

When not situated above or outside the limits of irrigation, or rendered unfit for cultivation by accumulation of alkali or seepage waters, they are of great agricultural importance, and are devoted mainly to the production of grains, sugar beets, alfalfa, stone or other tree fruits, and vegetables.

Bingham Series.—Of this series the gravelly loam has the highest agricultural value. It is chiefly adapted to fruit, such as apples, peaches, pears, cherries, plums and apricots, and in some localities to raspberries and strawberries. It is also suitable for growing wheat, alfalfa, and grains.

Jordan Series.—Of the Jordan series, the sand is the leading truck and fruit soil, devoted extensively to the production of tomatoes, peaches, plums, etc. It is somewhat leachy in character, necessitating frequent irrigation, and is sometimes injured by the rise of the water table when not naturally well drained. The loam is the leading sugar-beet producing soil of this series, being followed by the clay loam in adaptation to this crop. These two soil types are adapted to irrigation and are easily cultivated, but sometimes subject to injury from accumulation of alkali or seepage water. The fine sand usually occurs in wind-blown areas and is relatively unimportant. The clay is often poorly drained and alkaline, but when well drained is adapted to alfalfa and grains.

Malade Series.—The Malade series of Utah occur along the valley troughs. The sandy loam is usually free from alkali making a good soil for general farming. It is one of the best soils for sugar beets. The fine sand is also suitable for general farming purposes and for sugar beets when irrigated.

NORTHWESTERN INTERMOUNTAIN REGIONS.

The most extensive and uniform soil types of this region consist of residual materials overlying and derived from extensive basaltic lava plains and in some cases from granitic rocks or of ancient lacustrine sediments or extensive lake beds now more or less modified by erosion or æolian agencies. Owing to erosion by streams and to movements of the earth's crust, these soils now generally occupy more or less elevated sloping or rolling plains. About the margins of the lacustrine or residual deposits they are covered by sloping plains and fans of colluvial wash from the adjacent mountain borders, while in the vicinity of the larger streams, which have carved and terraced the lacustrine beds and residual soils, occur other series of recent alluvial stream sediments derived from reworked materials of the lake beds or from the weathered products of the mountains. It is the soils of this region that constitute a large portion of the great grain-producing lands of the Northwest.

Bridger Series.—The soils of the Bridger series are usually retentive of moisture and extensively utilized for the production of dry-farmed grains, consisting of wheat, oats, and barley, although irrigation is sometimes necessary for the production of these crops. Under irrigation, alfalfa, clover, timothy, and hardy fruits are also produced to a limited extent.

Yakima Series.—The soils of the Yakima series take high rank in the production of grains and of intensively irrigated fruits and other special crops. The stony loam and the sand usually lie above irrigation, are of porous structure, and frequently of wind-blown drifting character, and are relatively unimportant members of the series. The sandy loam is found in Idaho, where it is extensively developed. It is level and fitted for irrigation, but is yet but little used. The fine sand occurs in elevated areas, sometimes wind blown, but when capable of irrigation and cultivation is adapted to tree fruits, vegetables, small fruits, alfalfa, and clover. The fine sandy loam is the most highly developed and intensively cultivated member of the series, and is extensively devoted to the production of choice fruits, consisting of winter apples, peaches, cherries, etc., as well as truck crops, cereals, alfalfa, clover, timothy, and hops. The loam usually occupies elevated positions, and is frequently timbered when occurring in the vicinity of Lewiston and Moscow, Idaho, but these timbered tracts are now being cleared and devoted to wheat, oats, and flax, while the production of winter apples is successfully being carried on to a limited extent. In the Baker City area, Oregon, this type is devoted mainly to the production of oats, barley, and hay crops, but under irrigation is capable of successful culture to fruits and truck crops. The silt loam in the Gallatin Valley, Montana, is devoted to dry-farmed or irrigated grains, and when under irrigation also to the production of alfalfa and clover. In the Lewiston area, Idaho, and Walla Walla area, Washington, it covers large areas of the rolling upland, being devoted principally to the production of wheat and to a limited extent to vegetables, apples, cherries, and small fruits.

ROCKY MOUNTAIN VALLEYS, PLATEAUS, AND PLAINS.

The soils of the Rocky Mountain valleys, plateaus, and plains are derived from a wide range of igneous, eruptive, metamorphic, and sedimentary rocks. The plateau and plain types occupy a more or less elevated position and have sloping, undulating, or irregular surface features. They are derived from underlying sedimentary rocks or consist of the remnants of ancient extensive mountain foot-slope material or of alluvial deposits along streams trenching and terracing the sedimentary rocks of the plateaus and plains. The mountain slope and intermountain valley types consist of residual and colluvial deposits or of ancient lacustrine or later stream sediments, occupying mountain foot slopes and narrow valleys.

The soils of the mountain slopes are usually of little agricultural value, owing to their rough surface, elevated position, and the consequent impracticability of irrigation. Those of the plateaus, valleys, and plains vary widely in economic importance, depending largely upon climatic features, topographic position, and water supply for irrigation. They range from grazing lands of nominal value to soils adapted to the most important and intensively cultivated fruit, melon, sugar beet, and other special crops.

Billings Series.—Compact adobelike gray to dark or brown soils and subsoils, formed mainly by reworking of sandstones and shales and occupying old elevated stream terraces. This is an important series adapted to alfalfa and general farm crops and stock raising; also used to a considerable extent in the production of sugar beets.

Colorado Series.—Light-gray to reddish-brown soils and subsoils, derived from colluvial wash. Where irrigable these soils are important soils in the production of alfalfa, sugar beets, melons, and to a limited extent, fruits. A number of the soils of the series, however, are so situated as not to be susceptible to irrigation, and have not been developed for agricultural purposes.

Finney Series.—Brown to nearly black soils derived from glacial material underlain by lighter colored subsoils. The heavier soils may be dry farmed to advantage and would become very productive with irrigation. The lighter soils have a broken surface, are porous and easily drifted by the wind. They are best adapted to grazing.

Fruita Series.—Reddish-brown soils, formed by reworking of sandstones and shales, occurring as stream terraces. When well drained and free from alkali the members of this series are admirably adapted to the production of choice fruits, alfalfa, sugar beets, grains, and truck crops.

Laramie Series.—Dark-colored soils, with light-colored gravelly subsoils, derived from colluvial mountain wash. These soils have not been extensively developed owing to their elevation, and are used principally for grazing purposes.

Laurel Series.—Light-gray to black soils, underlain by river sands or gravels, occurring in good plains along streams. Under favorable moisture conditions these are fertile soils, adapted according to locality to corn, alfalfa, sugar beets, and truck crops, but the areas are often subject to overflow, and in some cases can not be drained.

Mesa Series.—Light-gray to brown soils derived from old flood-plain deposits, now elevated to form mesa lands. Where these soils have been developed and are susceptible of irrigation they are used mainly for alfalfa and sugar beets. One member of the series has been quite extensively and very successfully used for the production of apples and peaches.

Morton Series.—Brown residual soils, derived from sandstones and shales. The soils lie in the semiarid region, and give good yields of wheat, flax, oats, and potatoes when rainfall is sufficient.

San Luis Series.—Reddish-brown gravelly soils, formed from lacustrine sediments of volcanic rock materials. On account of the position and the danger from alkali these soils have not been successfully developed, but have been used mainly for pasturage and forage crops.

Wade Series.—Brown to dark-brown alluvial soils, formed by reworking of sandstones and shales. Used for oats, flax, millet, and wheat.

ARID SOUTHWEST.

The soils of the arid Southwest are mainly of colluvial, alluvial and lacustrine origin. They occupy mountain foot slopes, alluvial fans, debris aprons, or sloping plains of filled valleys, sloping or nearly level plains, and bottoms of stream valleys or sinks and drainage basins. The principal colluvial soils of this region are also common to the Pacific coast. The climate of the arid Southwest is characterized by semitropical desert conditions, and where the soils are not capable of irrigation they have little or no present agricultural value.

Gila Series.—This consists of recent stream deposits derived from a variety of rocks, and occurs over river flood plains and lower stream-formed terraces. The soils of this series are generally subject to overflow, and are often eroded or modified by torrential floods, cut by stream channels, more or less wind drifted, and frequently covered with dense thickets of willow, cottonwood, mesquite, canaigre, or other small timber or bushes. They are of light to dark brown color. The soils of this series are sometimes interstratified with minor layers of heavier sediments and are distinguished from those of the Imperial series by being underlain at varying depths by coarse river sands and gravels. The fine sandy loam and the fine sand, when irrigable and well drained, are well adapted to the production of fruit, truck crops, melons, potatoes, and alfalfa, but the surface is sometimes uneven and the soils are occasionally poorly drained or affected with alkali.

Imperial Series.—The soils are generally of light or reddish color, and in the heavier members are frequently poorly drained and filled with alkali. The sand and sandy loam are important types of this series adapted to the production of fruits, truck crops, and alfalfa or forage crops under irrigation. The clay loam and the clay frequently contain an excess of alkali salts and are cultivated with difficulty, owing to heavy or fine texture and compact structure, but if well drained are suitable for the production of alfalfa, sorghum, and millet.

India Series.—The fine sand is an important agricultural type of this series, adapted particularly to the production of sweet potatoes, melons, and vegetables. It is of special importance in the cantaloupe industry of the arid Southwest. It is also a good soil for forage crops. The fine sandy loam is adapted to the same crops, though often poorly drained and affected with alkali. In most cases the gravelly loam and the sand either lie above the irrigation systems or have a surface too uneven for irrigation; but when irrigable and free from alkali they are usually adapted to the production of fruits and vegetables.

PACIFIC COAST.

The soils of the Pacific coast, including those of the coastal and interior mountain ranges, foothills, and valleys, have been classified into a number of series, varying in field characteristics, topography, origin and mode of formation, and agricultural importance. They range from residual and colluvial soils of the mountain sides, foot slopes, and foothills, to deep and extensive river flood plains and delta sediments, and ancient and modern shore and marine lacustrine deposits. While some of these series are confined to a single coastal or interior mountain range or valley, others are of wider range and extend over several different physiographic regions. The value of these soils and their adaptation to crops is dependent largely upon the possibilities of irrigation and upon local conditions of rainfall and temperature, all of which are to a great extent dependent upon topography. They range in agricultural importance from those devoted only to extensive grain farming to the most valuable and in-

Destruction of Culvert Built Without Wing Dams. Dept. of Agr.
(See pages 149–165.)

Range Land Inside and Outside of Fenced Area, 1903. Dept. of Agr.

tensively cultivated lands devoted to citrus and deciduous fruits, vines, small fruits, and other special crops.

Fresno Series.—The sand and fine sand of this series, with intensive methods of cultivation and irrigation, are used for the production of peaches, apricots, cherries, prunes, figs, walnuts and raisin and wine grapes. They are also adapted to alfalfa and to vegetables under irrigation. The sandy loam and fine sandy loam are productive soils and excellently adapted to fruits and alfalfa.

Hanford Series.—The soils are usually productive and are specially adapted to fruits, vines, vegetables and truck crops, when well drained free from alkali and irrigated.

Maricopa Series.—The soils are generally of dark color and loose, porous structure. They are generally well drained and free from alkali, and where capable of irrigation are well adapted to fruits, vines, and general farm crops. The gravelly loam and the gravelly sand are well drained and free from alkali, but in many cases can not be irrigated, and are then devoted to grazing or dry-farming to grains or to the production of grapes. Extensive areas are, however, irrigated and used for the production of grains, grapes, citrus fruits, and stone fruits. In the San Gabriel area these types are used extensively for grains and for the production of citrus fruits. In the San Jose area large quantities of early peaches, apricots, prunes, other stone fruits, and grapes are produced. The sand is sometimes broken, hilly or wind-blown in character, but when favorably situated for irrigation is adapted to fruits, vines, and general farm crops. In the Ventura area it has been found a valuable soil for lima beans. The sandy loam and the fine sandy loam are usually free from alkali and well drained. Under irrigation they are good soils for alfalfa, grains, citrus fruits, deciduous fruits, small fruits, and truck crops. In the Los Angeles area they are devoted quite extensively to grapes, alfalfa, strawberries, lemons, and winter vegetables. The silt loam and the clay loam are not well drained, and accumulations of alkali occur. The best-drained areas produce alfalfa, wheat, barley, sorghum, and in some localities sugar beets.

Oxnard Series.—These soils are generally of a dark color. They are particularly adapted to the production of lima beans. They are also devoted to the production of walnuts, berries, truck crops and citrus and deciduous fruits. The heavier and slightly alkaline areas are usually best adapted to barley and sugar beets.

Placentia Series.—The soils of this series are derived mainly from granitic rocks, shaly sandstones, and sandstones carrying a large amount of granitic material. They are generally well drained, free from alkali, and frequently of somewhat refractory nature. They are tilled with difficulty, but possess marked moisture-retaining properties and include large areas of valuable lands devoted to grains, general farm crops, citrus and deciduous fruits, beans, and other special crops. The sandy loam, fine sandy loam, and loam are productive soils, and when irrigated are extensively devoted to citrus fruits, walnuts, olives, prunes, peaches, apricots, grapes, cherries, berries, and vegetables. They frequently occur, however, in extensive elevated areas above the reach of irrigation waters, and under such circumstances are usually devoted to the production of grains by dry farming. The sandy adobe, loam adobe, and clay loam adobe usually occupy sloping plains or an elevated position, are retentive of moisture, well adapted to dry farming of grains, and, when irrigated, to alfalfa, walnuts, and citrus and deciduous fruits.

Sacramento Series.—This is very important, covering a large area and varying widely in texture. The fine sandy loam is the most important prune soil in the Anderson Valley, having played a large part in the development of this industry in that section. It is also a good fruit soil generally, being adapted to peaches, pears, and grapes. Many of the orchards found upon it are in a high state of cultivation. It is also suited to alfalfa and vegetables, and when irrigated sugar beets may be grown upon it. To some extent it is dry-farmed to grain and to hops under intensive cultivation. The silt loam type of this series is devoted chiefly to grazing, but when irrigated it is adapted to alfalfa, sugar beets, and truck, as well as to sorghum and other forage crops. It is also dry-farmed to grain. In some places berries do exceedingly well and it also produces potatoes and hops of excellent quality. Citrus fruits are occasionally found on the silt loam. The gravelly sandy loam type is generally of little agricultural value. The heavier phases are better suited to crops, and when well irrigated will give fair yields of alfalfa and support good orchards. It is sometimes dry-farmed to grain. A very productive type of this series is the silty clay loam, upon which is grown to a considerable extent alfalfa and other forage crops, hops, fruits, and truck crops. In some places it yields excellent citrus fruits, but only to a limited extent. Under irrigation better results are obtained. The silty clay is used chiefly for grazing, but with a moderate amount of water alfalfa and sugar beets may be grown upon it. It is believed that with deep and thorough plowing and frequent cultivation fair yields of corn, sorghum, and other forage crops may be grown without water. When artificially drained and protected from overflow the clay loam type of the Sacramento series is very productive, producing timothy and other grasses, potatoes, onions, beans, etc. The greater part of the loam of this series is devoted to grazing, but when irrigated it is adapted to alfalfa, sugar beets, truck crops, and fruits.

Salem Series.—Residual, alluvial, or colluvial soils, either red or dark in color, derived from rocks or basaltic, schistose, crystalline, or arenaceous character. These soils, so far as they have been encountered, seem particularly adapted to hops, potatoes, and have been used to some extent for apples, peaches, and grain. They have not been very highly developed in the areas in which they have been encountered.

San Joaquin Series.—Compact red soils and subsoils derived from old marine sediments, usually underlain by red hardpan. These soils have been used almost exclusively for dry farming to grain on account of the general occurence of hardpan and very stiff and impervious subsoils. Recently in the Sacramento area some members of this series have been very successfully used for the production of the Tokay grape and strawberries.

Sierra Series.—Light-gray to red and frequently gravelly soils, often underlain by red adobe. Members of this series constitute some of the most valuable deciduous fruit soils of the foothills in northern California.

Sites Series.—Residual and colluvial soils of reddish-gray or dark-brown color, derived from sandstones, shales, conglomerates, and volcanic or altered material occupying low rolling foothills and their valley slopes, usually underlain at shallow depths by sandstones, conglomerates, or heavy subsoils. The Sites loam and clay loam adobe are the important soils of this series and are productive, but owing to their position are generally unirrigable and adapted to dry farming to grains.

Stockton Series.—Brown to black soils with heavy yellow subsoils, derived from old alluvial sediments. These soils have been used principally for the production of grain. The lighter members of this series have been adapted to fruit.

Willows Series.—Brown soils consisting of wash deposited by intermittent foothill streams. These soils have been used almost exclusively for dry farming grain crops. Large ranches are being broken up and brought under irrigation, and alfalfa and sugar beets are likely to prove the most important crops.

ALKALI SOILS.

The climate of arid regions is directly responsible for the prevalence of sandy soils containing large stores of water-soluble materials, which at once become productive upon the application of water. Even the most desolate stretches of desert will supply good crops if the needed water is applied, as is shown by the millions of acres of land now under cultivation that were formerly a barren desert. While this is generally the case there are a few exceptions, one of the most striking of which is when the soil contains alkali. Frequently alkali does not appear in an irrigated district until cultivation has been practiced for a number of years. The substances composing the alkali may be present in the soil before the application of water, or they may be brought in by the irrigation waters. In hot, dry weather, after rains or irrigation, the alkali frequently appears on the surface of the soil as a white crust.

Alkali consists of various chemical compounds (salts) which are often present in western soils in sufficient quantity to hinder or prevent the growth of plants. Most of these salts are familiar to everyone from their medicinal or household uses. The most common of these substances are Glauber's salt (sodium sulphate), table salt (sodium chlorid), and baking soda (sodium bicarbonate). The so-called black alkali is sal soda, or washing soda (sodium carbonate). Epsom salts (magnesium sulphate) is also an important ingredient of alkali in certain localities. All of these salts readily dissolve in water. Less soluble compounds that often occur in alkali soils are the carbonates of lime and magnesia and the sulphate of lime (gypsum, or land plaster).

It seldom, if ever, happens that only one kind of salt is present. Alkali is almost always a mixture of several salts, the kinds and the proportions in which they are mixed differing in different localities. But often some one salt forms the bulk of the alkali, and hence we can speak of sulphate alkali where Glauber's salt and other sulphates are the chief ingredients, of chloride alkali where common salt is the most abundant, and of "black alkali" where a considerable quantity of sodium carbonate occurs.

In many irrigated districts, especially in those situated east of the Rocky Mountains, Glauber's salt (sodium sulphate) forms the bulk of the alkali. But in some of the largest areas of alkali land in the United States common salt (sodium cholorid) is the most abundant compound present. Considerable quantities of sodium bicarbonate are often associated with both the sulphate and the chlorid types. The areas where black alkali (sodium carbonate) predominates are much more restricted.

The harmfulness of alkali depends upon the quantity as well as the kind of salts present. The alkali content of a soil is usually expressed in percentages of its total dry weight. Thus, if 100 pounds of dry soil contains 1 pound of salts that are easily soluble in water, its alkali content is said to be 1 per cent. As a rule, if the soil contains more than one-half of 1 per cent of white-alkali salts, only decidedly resistant plants can be grown.

The sulphates, chlorids, and bicarbonates, collectively known as white alkali, are much more abundant in most localities than the carbonates, or black alkali. Black alkali, which can usually be recognized by the dark color it imparts to the surface soil and to standing water, is far more injurious to plants than the white-alkali salts. It is a strong corrosive, causing the decay of plant tissues. Trees growing in black-alkali land are sometimes completely girdled at the crown through the corrosive action of the sodium carbonate. This salt also has a bad effect upon the texture of heavy soils, causing them to become puddled.

Where the soil contains considerable black alkali it is useless to attempt to grow crops until this condition is remedied. If gypsum, or land plaster, can be obtained at a reasonable cost, and the value of the land warrants its use, the black alkali can often be converted to less harmful salts by successive applications of this fertilizer. The effect of the gypsum is to neutralize chemically the black alkali. This results in loosening the soil, making it easier for water to penetrate, and aiding the washing down of the other salts. The presence of more than one-tenth of 1 per cent of sodium carbonate is injurious to the growth of practically all crop plants. For most species one-twentieth of 1 per cent (0.05 per cent) of this extremely noxious salt is too much for good crop production.

The white-alkali salts are not corrosive, but when freely taken up into the cells of the plant they cause serious disturbances in its nutrition. If present in the soil in sufficient quantity, these salts also hinder the absorption of water by the plant roots, so that even when the soil is quite wet the plants may actually be suffering from lack of water. This is doubtless one of the chief reasons why seeds germinate more slowly where alkali is present. The chlorid type of white alkali is somewhat more harmful to most crop plants than the sulphate type. The bicarbonates as such do not appear to be very injurious, but there is always danger where bicarbonates are present that black alkali will be formed by chemical action.

CHANGED SOIL NAMES.

The following list gives the soil names in published reports that as a result of subsequent correlation have been dropped. In the first column is given the original name; in the second, the name at present used.

Name as published.	Changed to—
Afton fine sandy loam	Miami fine sand.
Alamance silt loam	Cecil silt loam.
Allegan black clay	Clyde loam.
Allegan clay	Miami clay loam.
Allegan fine sandy loam	Miami fine sand.
Allegan gravelly loam	Miami gravelly sandy loam; Miami gravelly sand.
Allegan sand	Miami sand.
Allegan sandy loam	Miami sandy loam.
Allegan stony loam	Miami stony loam.
Almyra silt loam	Crowley silt loam.
Alton stony loam	Miami stony sandy loam.
Arkansas fine sandy loam	Wabash fine sandy loam.
Arkansas loam	Laurel loam.
Arroyo Seco sandy loam	Maricopa gravelly loam.
Austin clay	Houston clay.
Ayden fine sandy loam	Norfolk fine sandy loam.
Benton loam	Houston clay.
Billings sandy loam	Billings fine sandy loam.
Boise sandy loam	Boise silt loam.
Caldwell loam	Gallatin silt loam.
Caldwell sandy loam	Gallatin fine sandy loam.
Cecil mica loam	Chester mica loam.
Chicopee gravel loam	Norfolk gravelly loam.
Clarksville clay	Waverly clay.
Clarksville loam	Wabash silt loam.
Colorado adobe	Colorado loam adobe; Laurel loam adobe.
Colton stony clay	Crawford stony clay.
Connecticut Meadow	Meadow.
Connecticut Swamp	Swamp.
Dauphin sandy loam	Dekalb sandy loam.
Davie clay loam	Cecil loam; Cecil fine sandy loam.
Deer Flat saudy loam	Deer Flat fine sandy loam.
Dekalb clay loam	Lickdale clay loam.
Delavan silt loam	Sioux silt loam.
Donegal gravelly loam	Norfolk gravelly loam.
Durham sandy loam	Cecil sand.
Edgemont stony loam	Dekalb stony loam.
Edgerton silt loam	Miami silt loam.
Elkhorn silt loam	Wabash silt loam.
Elkton clay	Portsmouth silt loam in Mason County Ky.; and in all Maryland areas heretofore surveyed, and to Elkton silt loam in Delaware and New Jersey areas.
Elmira fine sandy loam	Wabash loam.
Elmira shale loam	Dunkirk shale loam.
Elmira silt loam	Dunkirk silt loam.
Elsinboro fine sand	Norfolk fine sand.
Elsinore sandy loam	Elsinore fine sandy loam.
Fairview sandy loam	Marshall sandy loam.
Fancher sandy loam	Stockton fine sandy loam; Hanford sandy loam.
Fargo gravelly loam	Marshall gravelly loam.
Fargo loam	Marshall loam.
Fort Payne clay	Conestogo clay.
Fort Payne loam	Hagerstown loam.
Fort Payne stony loam	Clarksville stony loam.
Fresno gravel	Hanford gravel.
Fresno gravelly sand	Maricopa sand.

Name as published.	Changed to—
Fresno red sand	San Joaquin sand.
Fullerton sandy adobe	Placentia loam adobe; Placentia sandy adobe.
Galveston coarse sand, sand, and fine sand	Coastal beach.
Galveston sandy loam and clay	Tidal swamp and marsh.
Garner stony loam	Susquehanna gravelly loam.
Glendale loess	Glendale clay loam.
Glenwood loam	Bingham loam.
Goldsboro compact sandy loam	Portsmouth sandy loam.
Hagerstown shale loam	Dekalb shale loam; Volusia silt loam.
Hagerstown silt loam	Clarksville silt loam.
Hanover sand	Miami sandy loam.
Hartford sandy loam	Merrimac sandy loam.
Hempfield stony loam	Cecil stony loam.
Hempstead gravelly loam	Hempstead loam.
Herndon stony loam	Porters stony loam.
Hondo meadows	Meadow.
Houston silt loam	Houston loam.
Imperial fine sandy loam	Gila loam.
Imperial gravelly loam	Indio gravelly loam.
Imperial loam	Imperial clay loam; Gila clay loam.
Imperial silt loam	Gila silt loam.
Janesville loam	Sioux silt loam.
Janesville silt loam	Marshall silt loam.
Jordan meadow	Meadow.
Jordan sandy loam	Jordan fine sandy loam; Jordan loam.
Kalamazoo gravelly loam	Clyde gravelly sand.
Kaskaskia loam	Wabash silt loam.
Leonardtown gravelly loam	Leonardtown loam.
Lincoln sandy loam	Laurel fine sandy loam.
Los Angeles sandy loam	Placentia loam.
Lufkin clay loam	Lufkin clay.
Mackinaw gravel	Miami gravel.
Maricopa sandy adobe	Colorado loam adobe; Placentia sandy adobe.
Maricopa stony loam	Bingham stony loam.
McLean silt loam	Marshall loam.
Miami black clay loam	Marshall black clay loam.
Miller heavy clay	Miller clay.
Monroe fine sandy loam	Miller fine sandy loam.
Murrill sandy loam	Hagerstown sandy loam.
Murrill stony loam	Hagerstown stony loam.
Norfolk sandy soil	Norfolk sandy loam.
Oakland sandy loam	Miami fine sandy loam.
Orangeburg silt loam	Miller silt loam.
Oswego loam	Oswego silt loam.
Pecos gypsum	Gypsum.
Pecos sand	Gila fine sandy loam: Gila fine sand.
Placentia coarse sandy loam	Placentio sandy loam.
Plainwell stony loam	Miami stony sand.
Pocoson	Swamp.
Porters red clay	Potters clay.
Portsmouth clay	Portsmouth loam.
Quinton sandy loam	Norfolk sandy loam.
Redfield sandy loam	Redfield fine sandy loam.
Rio Grande loam	Laurel clay loam.
Rio Grande sandy loam	Laurel sandy loam.
Roswell sandy loam	Roswell fine sandy loam.
Salem loam	Salem silt loam.
Salem sandy loam	Salem fine sandy loam.
Salinas shale loam	Oxnard gravelly loam.
Salt River adobe	Gila clay.
Salt River gravel	Rough stony loam.
San Gabriel gravelly loam	Maricopa gravelly loam.
San Gabriel gravelly sand	Maricopa gravelly sand.
San Gabriel sandy loam	Maricopa sandy loam.
San Jacinto clay	Houston black clay.
San Joaquin black adobe	Oxnard clay loam adobe; Billings clay, Stockton clay loam adobe.
San Joaquin red adobe	San Joaquin clay loam adobe; San Joaquin sandy adobe.
Santiago sandy loam	Santiago fine sandy loam.
Santiago silt loam	Hanford clay loam; Gila loam; Gila silt loam; Gila clay loam; Hanford silt loam; Laurel loam.
Savanna	Swamp.
Sedgwick clay loam	Marshall silt loam; Crawford silt loam.
Sedgwick gravelly loam	Crawford gravelly loam.
Sedgwick loam	Colorado loam.
Sedgwick sandy loam	Colorado sandy loam.
Selma clay	Norfolk clay.
Selma heavy silt loam	Portsmouth sandy loam; Portsmouth fine sandy loam.

Name as published.	Changed to—
Selma silt loam	Norfolk sandy loam.
Shelby clay	Shelby loam.
Sierra adobe	Sierra sandy adobe; Placentia clay loam adobe.
Sierra loam	Sierra loam adobe.
Snake River sand	Yakima fine sand.
Soledad gravelly sand	Maricopa gravelly sand.
Sturgis fine sandy loam	Norfolk fine sandy loam.
Sunnyside sand	Yakima fine sand.
Susquehanna gravel	Norfolk gravel.
Tazewell silt loam	Miami silt loam.
Triassic stony loam	Penn stony loam.
Vernon fine sand	Miller fine sand.
Vernon loam	Vernon silt loam.
Volusia sandy loam	Volusia loam.
Waldo loam	Wabash silt loam.
Walla Walla loam	Walla Walla silt loam.
Warwick sandy loam	Norfolk coarse sandy loam.
Westphalia sand	Norfolk fine sand.
Willis sand	Norfolk fine sandy loam.
Windsor sand	Norfolk coarse sand.
Winnebago sandy loam	Marshall sandy loam.
Yakima gravelly loam	Gallatin gravelly loam.
Yakima sandy loam	Yakima silt loam; Yakima loam; Yakima fine sandy loam.
Yakima stony clay	Rough stony land.
Yazoo clay	Waverly clay; Crawford clay; Wabash clay.
Yazoo heavy clay	Wabash heavy clay.
Yazoo silt loam	Wabash silt loam.

—.(Bu. Soils, Bs. 15, 16, 17, 22, 23, 24, 25, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 44, 45, 46, 47, 48, 49, 55; Purdue Univ. B. 33; R. I. Ex. Sta. B. 68; Univ. Wis. B. 204; Bu. of Soils B. 35; F. B. 446; F. B. 88.)

Effects of Climate on the Soil.—The differences in climate not only affect the plant directly but have a great effect upon the soil and its chemical properties or composition—particularly in regard to the chemistry of its organic constituents—making the soil to this extent a different soil and thus affecting the plant.

The first condition determining the proper agricultural use to which any soil can be put is climate, which limits broadly the zone or area in which certain field crops can be grown, and which affects the yield and quality of the products to a very marked degree, even within the area of profitable cultivation. The climate of the continental United States varies greatly, probably much more than is generally realized.

In the southwest we have the semitropical arid climate; in southern Florida the semitropical humid climate. Over the country as a whole we have from more than 60 to less than 10 inches of rainfall and a range of mean temperature of more than 70° F. to less than 40° F. The elevation of our arable lands varies from below sea level to over 6,000 feet above. We also have varying types of rainfall; the greatest precipitation may occur in the winter months or may come in the summer months. We have great differences in relative humidity and in sunshine; differences in the range of temperature, both seasonal and daily, and differences in the length of the growing season. Finally, differences due to slope, exposure, large bodies of water, and to other conditions too subtle to measure, which may determine the special fitness of a soil for a particular grade or quality of product. So complex are all these conditions and so indeterminate their individual or combined influence on the crop that no exact expression can be given for the climatology of any particular locality.

While it is not possible as yet to give an expression to meteorological data which will be a sufficient guide to crop characteristics, it is possible by careful observations of crops and native vegetation to form very accurate estimates of crop possibilities and to define areas in which certain crops having certain qualities can be produced. Such an area as the tobacco area of the Connecticut Valley is a case in point; also areas producing sugar beets, sweet corn and some varieties of fruits. There are special localities where grapes are known to do exceptionally well. The Albemarle pippin, which grows best on one particular soil, takes on its highest color only when grown on this soil in sheltered coves between certain elevations in the Blue Ridge Mountains.

The farmers of the United States spend vast sums of money each year in trying to find out whether a particular fruit, vegetable, or cereal will or will not thrive in localities where it has not been tested. Most of these experiments result in disappointment and pecuniary loss. It makes little difference whether the crop experimented with comes from the remotest parts of the earth or from a neighboring State, the result is essentially the same, for the main cost is the labor of cultivation and use of the land. If the crop happens to be one that requires a period of years for the test, the loss from its failure is proportionately great.

The cause of failure in the great majority of cases is climatic unfitness. The quantity, distribution, or interrelation of heat and moisture may be at fault. Thus, while the total quantity of heat may be adequate, the moisture may be inadequate, or the moisture may be adequate and the heat inadequate, or the quantities of heat and moisture may be too great or too small with respect to one another or to the time of year, and so on. What the farmer wants to know is how to tell in advance whether the climatic conditions on his farm are fit or unfit for the particular crop he has in view, and what crops he can raise with reasonable certainty. It requires no argument to show that the answers to these questions would be worth in the aggregate hundreds of thousands yearly to the American farmer.—(Y. B. 1897; Bu. of Soils B. 55.)

Utilization of Soils.—The art of soil management is to so manipulate and handle 4,000,000 pounds of raw material—the weight of soil 1 foot deep on an acre—at an average cost of $10 or $12 as to produce the greatest quantity of food and clothing and still leave the soil unimpaired for future generations. The highest art is usually ascribed to the individual who secures the greatest net returns in money or the best grade of product. The best chance of attaining the highest art is in the long run in the hands of the man who has a thorough understanding of the nature of the soil and how to handle it, of the crops adapted to it and their needs, and of the market demands; in other words, who can make the most of the proper utilization of the conditions and resources above mentioned.

Drainage conditions, as such, have much to do with soil utilization. Certain crops like rice will produce well only when the soil is submerged with water for considerable periods of their growth, and structure has much to do with ease of flooding and consequently with cost of production. Others, like cranberries and peppermint, will do well in bogs; celery, onions, cabbage, and potatoes do well on muck if properly drained; pineapples grow on the loose beach sand of Florida, which is excessively drained.

It is not unusual to find the character and depth of the subsoil influencing the drainage conditions of a field and affecting the utilization of the soil. This is particularly marked in the case of tobacco in southern Virginia and in North Carolina, where a few inches difference in the depth of the clay subsoil below the surface means the difference between the utilization of the soil for bright leaf cigarette tobacco or the heavy types of export or manufacturing tobacco. Such variations also affect very materially the yield of wheat and other crops, and thus influence the proper utilization of the soil.

Elevation and exposure are important factors in the utilization of soil. Examples of this are seen in the fine quality of grapes on the terraces and slopes in the lake region of New York, Pennsylvania, and Ohio; in the protection from frost and the consequent early maturity of truck crops on the peninsulas of the Atlantic Coast States; in the protection from frost on the foothills and mountain sides. Citrus fruits can not safely be grown upon soils which would otherwise be adapted to them in the San Joaquin Valley, California, but are grown very successfully on the foothills bordering the valley. Peaches are successfully grown on the Maryland-Delaware peninsula and in the mountains of western Maryland, but not with safety on the intervening Piedmont Plateau (although the soils are otherwise well adapted to the fruit), on account of frosts which are liable to occur when the fruit buds are so far advanced as to be easily killed.—(Bu. of Soils B. 55.)

Adaptation of Soil to Crops.—The principles governing the adaptation of soils to crops may be briefly stated. The plant must have in the soil and in the atmosphere a congenial and sanitary environment. The plant is fixed in position in a medium which has previously been occupied by a crop, and which has thrown off waste products. The sanitation of the soil must provide for the absorption and change to harmless forms of such waste products.

Soils under different climatic conditions, with differences in elevation, slope, drainage, and from certain obscure chemical powers, apart from differences of texture, are able to provide more or less perfectly efficient sanitary conditions for certain crops.

That these differences of adaptation of soils to crops do exist is clearly indicated by the fact that natural plant associations differ for all types of soils which have been encountered, both as to kind of plants and relative numbers of the different species. The prevalence of certain trees or weeds frequently offers safe indications of soil conditions and of crop adaptations.

The character of the native vegetation frequently affords a very safe guide to the prevalence and amount of alkali salts contained in the soils of any particular locality. Some native plants are not found where the salt content exceeds 0.20 per cent. Other plants are characteristically found where the salt content is very much higher. These indications, however, differ in different places, and for different types of alkali.

It is a well-known fact that cultivated crops differ as regards the amount of alkali—and this varies with the character of alkali—which they can withstand. Alfalfa is exceedingly sensitive. Sorghum and sugar beets, on the other hand, are very resistant. In the development of the tobacco interests in the Miami Valley, Ohio, the sugar maple was taken as a safe indication of the soils on which the best grades of tobacco could be produced.

Perhaps nowhere is the use of character of the native vegetation as a guide to the utilization of soils more marked than in certain areas in Florida. With little or no observable difference in the character of the soils, the hammock land, with its luxuriant growth of hardwood trees, is considered the strongest and most reliable land for the general crops of the locality. The high pine land, with its sparse growth of well-developed pine, is second in importance, being adapted, under intensive methods of cultivations, to the production of early truck and vegetables, though rather less valuable for citrus fruits than the hammock land. The lighter members of the sandy types, if not too coarse, are adapted to the early spring vegetables, the intermediate loam types are adapted better to wheat, corn, cotton, and general farm crops, under suitable climatic conditions, and the heavy clay types are better for grass and soiling crops for dairying and stock raising. This is general over the eastern half of the United States, but not specific, as there are many modifying influences. For instance, a rather fine sand in a low situation where a more moist condition than usual is maintained produces good yields of wheat. Also, after the intensive fertilization given truck or tobacco a good crop of wheat may be produced on land too light for profitable culture in this crop under general farm methods. It may therefore be given a place in rotation with special crops when it would not be advisable to grow it under less intensive culture given other crops. Also when clover runs out and has to be omitted from the rotation it is often inadvisable to grow wheat on a soil which would otherwise be considered suitable, because the yields can not be maintained without the intervening clover crop.

Corn may often be recommended for a soil not particularly adapted for this crop, because of its value in the rotation and as a necessary feed for farm stock. Such utilization of soils is only justified when other crops equally valuable for forage and grain and better adapted to the soil can not be found.

The structure of the soil as determining the compactness and affecting root penetration and æration, as well as drainage conditions, has much to do with crop adaptation. The crawfish lands of Tennessee are extreme types of soils which run together when wet into an almost impenetrable mass.

Economic conditions are changing constantly, and these may make of great value soil areas that heretofore have scarcely been considered worth cultivation. The introduction of bright yellow tobacco in North Carolina, for instance, increased the price of the sandy lands tenfold. Some of the sandy types, which thirty or forty years ago would have been classed as of low rank, have by special adaptation to truck growing been changed during the last generation to a position of the highest rank. Similarly, by reason of special adaptation, some of the stony loams and clays have passed from the lower to the higher ranks.

The peculiar adaptation of soils to special crops has long been recognized. The hot-house lettuce of Boston has been esteemed the finest product of the kind received in the New York markets. The soil used for the production of this lettuce is peculiar to the locality. It is probable that some of the soils which are regarded as unproductive and unsuited to the production of staple crops, may be found peculiarly adapted to new crops for food, drugs, or fibre, or plants might be adapted to them by introduction and breeding. Thus the light sands of the Coastal Plains, which a few years ago were considered quite worthless for agricultural crops, have become profitable by the introduction of truck crops. Also the utilization of the valueless coast prairie lands of Louisiana and Texas for rice culture, by the introduction of a variety of rice from Japan. There are large areas of soils in the United States not now profitably cultivated to crops because they are unsuited to any of the staple crops.

Much is being accomplished through the development of irrigation systems, as well as through the reclamation of swamps and overflowed lands adapted after reclamation to special crops of high value, for example, truck crops, peppermint, celery, onions, and the like. We have, however, an apparently even more difficult problem in the utilization of some of the extremely sandy soils or barrens, where the sand is so loose and incoherent, so deep and dry, that none of our present crops are adapted to them. We also have large areas of gravel soils and stony soils that are of little use, although with the same amount of gravel and stones in other soils we can adapt them to very profitable purposes. We also have the extreme types of plastic clays, like the Susquehanna clay, covering large areas, very poorly adapted to any of the common crops, poorly adapted to fruit or forest growth, and which are so costly to improve that they are at present practically useless for profitable agriculture. It would seem that some kind of crop or some industry could be devised for the profitable utilization of these at present useless lands if the problem were conscientiously studied. We have the utilization of vast areas of cut-over pine lands, and the people have to decide whether these can most profitably go back into forests, or, if taken up for agricultural holdings, what crops and what methods of cultivation can be adapted to them? Some of these lands it is known are strong agricultural soils, while others are known to offer such difficulties to the production of economic crops as to make the problem of their adaptation extremely difficult.—(Bu. of Soils B. 55; Y. B. 1906; Univ. Ill. B. 124; Y. B. 1909.)

RELATION OF THE SOIL TO PLANT NUITRITION.

The old idea of soil fertility was that plants could not avail themselves of the potash or phosphoric acid until the rock particles, the minerals, were decomposed and their constituents made available to the plants. It is, however, merely a question of the solubility of the mineral particles themselves. One can take the minerals obtained from the soil, or minerals from museum collections, and by grinding them up and adding water and a little nitrate can get a soil solution which is comparable with the soil solutions of our fields, and can grow as good plants in the extract from the cabinet specimens so prepared as in the extract of the soils itself. The plants can avail themselves of the potash, phosphoric acid, and lime which are dissolved directly from these mineral particles. Not only so, but if we take these minerals and wash them by repeated leachings, we will continuously get quantities of potash, phosphoric acid, and lime dissolved in the water. After leaching repeatedly and frequently during the day, if we leave the particles in contact with a fresh portion of water overnight, in the morning the concentration of the solution will be about the same as it was the morning before, so immediate and rapid is the recovery and so adequate and ready is the supply of these mineral nutrients.

We have in our soil moisture a solution which carries sufficient mineral nutrients for the support of the plants. It is capable of maintaining its concentration by re-solution from the minerals to supply any portion of these plant food constituents that may be withdrawn. Under ordinary conditions of drainage and of rainfall the concentration can not get too large, nor can it for any considerable period get too small for the need of plants. In other words, we have in the soil a most efficient system for supplying the nutrient food for plants.

This, therefore, is the nature of the soil and of the soil moisture. It is a great nutrient medium for the support of plants, spread out over the surface of the earth, and as all soils, with but possibly few and unimportant exceptions, are made up of a great number of minerals, it follows that the concentration and the composition of the soil moisture in our different types of soil varies but little. One might expect to find that in such extreme cases as the heavy clay soils of the limestone Valley of Virginia, the black prairie soil of Texas, or the Norfolk sand of the Coastal Plains there would be marked differences in the composition of the soil moisture, but investigations show that the moisture has about the same composition in each of these widely different types of soils, or at least differences as do occur are not sufficient to explain the observed differences of crop adaption and yield.

Ten elements are essential to the growth and development of all plants. They are carbon, hydrogen, oxygen, magnesium, iron, sulphur, calcium, nitrogen, phosphorus and potassium. Combinations of the three elements, carbon, hydrogen and oxygen, constitute approximately 95 per cent of all plants. They form the portions spoken of in feeds as fats and carbohydrates, including the oils and starch. Plants obtain their supply of these elements from air and water. The carbon is derived from the carbon dioxide of the air, and the hydrogen and oxygen from water, which is a combination of these two elements. Thus, it is seen that only about 5 per cent., or one-twentieth of the material of plants, actually comes from the soil. Only minute amounts of magnesium, iron and sulphur are required, and they are present in practically all soils in abundant quantities. The same is usually true as regards calcium although certain crops, particularly clover, require this element in considerable amounts. It is evident that seven of the ten elements essential to plant growth need cause the farmer but little concern.

Nitrogen, phosphorus and potassium are three elements which in their various combinations constitute the vast majority of the material obtained from the soil by plants. These elements are required by all plants in considerable amounts and their presence in many soils is limited. It is a common but erroneous idea that the soil is a great mass of material, the greater portion of which may sooner or later be used by plants as food. Numerous chemical analyses of soils, representing many different sections, show that a ton of fertile soil to a depth of one foot does not contain on an average more than 10 or 12 pounds of nitrogen, phosphorus and potassium.

Nitrogen, phosphorus and potassium are always found in small amounts even in the most exhausted soils, but if any one of these three elements is present in too small an amount to meet the full demands of a crop, the growth and yield of the crop will be correspondingly decreased. These elements do not exist in the soil as single elements, but are found combined with other elements, and it has been demonstrated by experiment that plants are capable of appropriating their food only when it exists in certain combinations. In other words, sufficient amounts of plant-food may be present in the soil, but it may be in such form that plants cannot use it. Herein lies the solution of the soil fertility problem, so far as plant food is concerned, viz, to have present at all stages of the plant's growth an ample supply of each element in a readily available form.

It is probable that most of the material in the soil, in order to be available to crops, must be soluble in water, at least in the soil moisture which contains carbon dioxide and other compounds coming from the decomposition of vegetable matter. This is indicated by the fact that crops can be grown to maturity in water solutions of the necessary elements without any soil whatever, and also, that plants do not grow in soils altogether deficient in water soluble materials, although only a small amount is needed. Fortunately, processes are continually going on in the soil by which the combinations of the different elements are changed gradually so that small amounts of water soluble salts are being formed from those which are insoluble. This gradual change from one form to another is the chief explanation of the increased fertility.—(Bu. of Soils B. 55; Tex. Ex. Sta. B. 126; F. B. 257; Iowa Col. B. 95; Univ. Wis. B. 139.)

SOIL FERTILITY.

The efficiency of any soil is measured by its capacity to supply plants with the several materials and conditions they require for growth. These include food, water, heat, air, and support; and in addition the soil must be free from various diseases and animal enemies that, in spite of a proper supply of all the essential conditions of growth, may still prevent productiveness. In proportion as any particular soil supplies all these essential conditions in well-balanced abundance, the largest growth of plants may be obtained. Again, if these conditions are deficient or improperly balanced by the shortage of one of their number, a lower or more simple type of plant or a smaller growth will result. Difference in soil conditions results in different kinds of plant growth. Thus, wheat is grown on deep, fertile loam, and mosses and ferns on thin, rocky slopes, truck crops are grown on dry, warm sand, and sphagnum or sweet flag on mucky marshes. The great variety in plants is due to the great variety of soil conditions.

The soil is the greatest natural resource of the Nation. With the exhaustion of coal and iron it will supply, if rightly used, not only food and clothing as at present, but also fuel, light, power, and structural materials now supplied to a greater or less extent by these minerals. It produces now over $7,000,000,000 in products annually, forming a basis of our industrial wealth and a large proportion of the foreign exports, yet we are but now taking up the last of the public lands available for cultivation and the country is still so sparsely settled that only about a quarter of the land nominally in farms is actually under cultivation.

From these lands we are getting only a third or a half the yield per acre obtained on the older soils of Europe, and within the past fifty years we have seen in many individual farms the productivity of our new soils decline more than in equal proportion to the increase in productivity of European countries. The population of the country is rapidly increasing and the time has surely come when we must face the situation and when we should take an account of stock and deliberate as to what should be done to increase the returns from the land and yet leave the soil in better condition for succeeding generations. The soil is the one natural resource which, if properly used, not only clothes and feeds us, but improves with age and careful treatment for the continued use of posterity.

There are in the United States soils which, so far as known and within historic times, have never been productive, although under climatic conditions favorable to crops. Besides some of the very dry coarse sands and gravel we have as examples the Elmwood loam of Connecticut, the Conowingo loam of North Carolina, the Monroe silt loam of Louisiana, and the scrub lands of Florida. Other soils are noted for their great and lasting fertility. Examples of this class are the Dunkirk soils of New York, Hagerstown soils of Pennsylvania, Maryland and the Valley of Virginia, and the bluegrass regions of Kentucky, the Marshall soils of Iowa, the Houston soils of Alabama, and the Yazoo soils of the Mississippi Valley.

Plants in their growth make use of thirteen chemical elements, nine of which they secure directly from the soil. These are called the mineral plant foods; they are phosphorus, potassium, calcium, magnesium, sodium, iron, silicon, chlorin and sulphur. The rock particles are of many kinds, but nearly all kinds contain more or less potassium, calcium, phosphoric acid, etc. Every year the soil water dissolves off a thin surface layer from each particle. Plants appropriate this water and thus secure mineral plant food.

Many generations of plants have thus been collecting their small toll of food from the soil and storing it up in their tissues. The amount of plant food made ready for plant use during each growing season through the slow solution of the mineral particles of the soil is doubtless supplemented to a considerable degree by the same kinds of material set free from the organic matter also found in the soil—that is, the mineral matter originally secured from the dissolved minerals, but built into plants during some former season, may again be used by other plants when the old matter is given an opportunity to decay in the soil. These foods derived directly from the mineral matter of the soil and indirectly from it through the growth, death, decay, and return of former crops are also supplemented in many cases by the application of mineral matter in the form of commercial fertilizers.

In addition to the nine elements already mentioned, the growing plant requires four other elements, as follows: Hydrogen, which it secures from water (water is a compound of hydrogen and oxygen); oxygen, which it secures partly from water and partly from the air; carbon, which is secured from carbonic-acid gas in the air; and nitrogen.

Nitrogen is in many respects the most important of all the plant-food elements. It is not found in appreciable quantities in the rock particles of the soil. Ordinary plants depend for their nitrogen entirely on decaying organic matter. As decay proceeds nitrates are formed from the nitrogen contained in organic matter. The nitrates are exceedingly soluble, and unless soon made use of by growing crops are washed out of the soil. Nitrogen is therefore usually the first element to become exhausted in the soil.

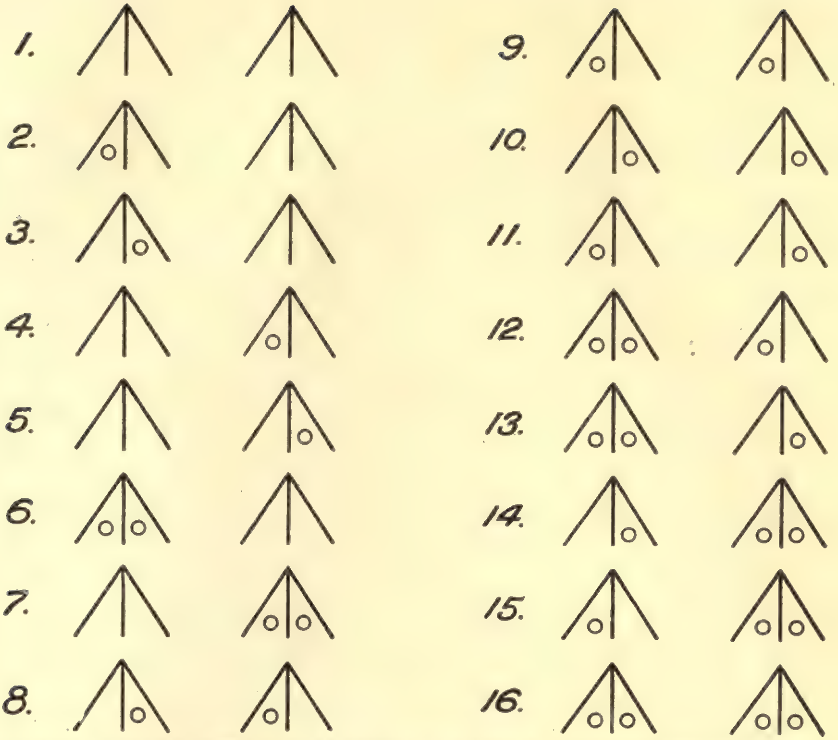
Plants take up these mineral plant foods only in solution in the soil water. In other words the mineral grains in which the bulk of this plant food is locked up must gradually dissolve and give to the soil water these materials in solution if they are to be absorbed by the plant roots. This means that there exists in the soil first, what is termed unavailable plant food, or that existing in these mineral grains and in the humus in more or less insoluble form; and, second, available plant food or that which is gradually dissolved from this rather insoluble supply. The larger part of the mineral plant foods in all soils exists in this unavailable form and since the dissolving action goes on very slowly there is in most soils only a very small part of the total supply that is soluble or available at any one time. The problem of the farmer is therefore to keep within the soil sufficient soluble nitrogen, phosphorus and potassium for maximum yields.

There are certain agencies which aid in making available the insoluble plant food of a soil, the most important being the action of decaying humus. When humus decays, certain organic acids are set free, which, as they are taken up by the soil moisture, enable it to dissolve this mineral plant food more rapidly. Other agencies have a place in this action but it is to the presence of considerable quantities of decaying humus that the larger part of this dissolving action is due. Considerable quanities of plant food are also fixed within the humus itself and as it decays these are made soluble. These two factors are in large measure responsible for the great productiveness of virgin soils containing large amounts of humus, as well as for the very beneficial effects of adding humus to a worn soil.

The fact that the supply of available plant food in a soil is largely determined by the quantity of humus present gives to this constituent of soils a very great importance. Moreover, there are various other ways in which humus acts beneficially, such as in preserving a friable condition of the soil, in conserving moisture and in preventing washing. Humus is almost invariably associated with fertility. It is to the presence of humus that the dark color in soils is usually due and a dark color is almost always indicative of a fertile soil.

The fertility of the soil is dependent upon four principal facts, viz: Plants must breathe, must drink, must feed, and have a proper sanitary environment.

All understand that the breathing of the plant is mainly through its leaves; but the soil also may be a very important factor in the breathing of plants, as it is necessary to have a supply of oxygen around the roots. Physiologists differ as to the office the roots have in regard to the absorption of oxygen. Whether it is a true breathing, the taking of oxygen for the plant economy through the roots as through the leaves, has never been decided; but it is unquestionably a fact that roots of cultivated plants require oxygen around them for their healthy growth. We know that cultivation of the soil is important or necessary for the best development of many crops, and say that it is in order to introduce oxygen and make possible the introduction of more water into the soil. It seems necessary not only to introduce air into the soil, but by stir-



Sixteen Different Ways of Marking the Feet of Poultry Dept. of Agr.

A Well-Constructed Poultry House.
Dept. of Agr.

A Crudely-Constructed Poultry House.
Dept. of Agr.

ring the soil to permit the escape of noxious gases that are perhaps given off by the plants themselves or produced by bacterial action on the remains of excreta of plants.

The root of a plant is absorbent for water and for mineral matter only at the tip and for a very short distance back from the tip—only a small fraction of an inch. It is something like one-tenth of an inch of the root that actually absorbs water and mineral food. This portion of the root is only absorbent for a few days, probably for not more than three or four days. As the tip is extended into new fields of moisture and plant food, the part that was absorbent yesterday ceases to be absorbent today. There is therefore no reason why water should move up to the plant from any considerable distance, for the plant itself constantly moves its feeding roots out into new fields.

Next to temperature, moisture is probably the controlling factor in the growth of plants. The importance of an adequate supply of moisture is most strikingly demonstrated in regions of deficient rainfall where irrigation is necessary for the growth of crops (arid regions), but it is no less important in regions where the rainfall is usually considered sufficient for the needs of crops (humid regions). Not only must there be a sufficient supply of moisture, but it must be properly distributed throughout the growing season. It is well known that crops may be injured by drought in a season which shows a high total rainfall, because there is a deficiency of rain just at the stage when the plant needs it most.

A proper circulation of air in the soil is just as important as any other factor of plant growth. Nearly half of the volume of ordinary soils is occupied by air spaces. The air spaces in the soil wind in and out between the soil particles, just as they do in a pile of larger stones. If the layer of water on the surface of the soil grains becomes so thick as to stop the air passages here and there the soil is then too wet for most crops and needs drainage. Plants have no special breathing organs, the oxygen required in their breathing finding entrance all over the surface of the plant. Plant roots must therefore be supplied with air, and hence the soil must be porous enough to admit of free circulation of air. A good supply of humus and proper tillage will accomplish this result in clay soils. Sandy soils are usually too porous, needing humus to help them retain water.

PERMANENCY OF SOILS.

The soil is the one indestructible, immutable asset that the Nation possesses. It is the one resource that cannot be exhausted; that cannot be used up. It has been said that dairying is injurious to the soil; the same statement has been made in regard to lands in England. A writer in a recent publication says on that subject:

It is rather strange at this time of day, after all that has been said and written on the subject, to find anyone harking back to the old fallacy that the keeping of milch cows impoverishes the land. In Cheshire dairying has been carried on for seven centuries, yet a small dressing of bones renovated the pastures within our times. In my native county of Ayr dairying has been carried on for two and a half centuries, yet I have never heard of any impoverishment, but the contrary, and I affirm that if any alleged case of impoverishment is inquired into it will be found to be either mythical or due to exceptionally bad management. In my own case, where twenty years ago it took 2½ acres to graze a cow during the summer, those same fields now require 1½ acres to do the same, and on one occasion 1 acre per head was sufficient—their droppings have so enriched the land.

It has long been a mystery how soils have continued to support crops for a thousand years and more, and the mystery becomes deeper when we realize that in the oldest cultivated countries there is no sensible diminution of plant food. We have the general history of China that goes back probably for four thousand years. There are many sections of that country that have undoubtedly supported a population for at least as long a time as that. It is said that they are very careful to return the excrement both from man and animals to the soil, but there must be some loss, some waste, and in four thousand years this would amount to considerable. But there are no signs of deterioration of these soils. There is no evidence that these soils are going back, and the fact that they have been careful in their cultivation only goes to show what we can do with our soils if we exercise reasonable care.

Coming down to more recent times, of which we have actual statistical records, it can be shown that so far as statistics can be relied on, without going back of the returns, without finding out how these statistics were taken, and just what value they have, the soils of the world, or at least of the European countries, are not wearing out, but that they are actually improving.

Statistics for the whole of Europe from 1876 to 1904 show a gradual increase in yield per acre of all cereal crops. Wheat has increased from 12.90 to 15 bushels; rye from 11.84 to 14.08 bushels; barley from 17.86 to 18.62 bushels; oats from 24.08 to 27.16 bushels. The details are given in the accompanying table.

Yield of Cereals in Europe.

Year	Wheat	Rye.	Barley.	Oats.	Year.	Wheat.	Rye.	Barley.	Oats.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*		*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
1876-1880...	12.90	11.84	17.88	24.08	1891-1895...	14.10	13.28	19.76	26.32
1881-1885...	13.65	12.16	18.43	24.36	1896-1900...	13.95	14.08	18.62	27.16
1886-1890...	13.50	12.48	18.62	25.20	1901-1904...	15.00	....	....	....

The records of Denmark, Holland, Belgium, Norway, Austria, and other European countries for which data are available show continued increase in the yield per acre of cereal crops, as in the cases cited above.

From this historical evidence it appears that on these old soils of the old countries, which have been under cultivation for a thousand years, the yields within the last century have actually increased, as shown not only by general statistics gathered by the

States, but by the statistics of individual farms which have been continually under the management and in the possession of the same families. This shows that, so far from wearing out, these soils have been steadily increasing in productivity within the period of which we have statistical records. This increase is due to better methods of cultivation, more systematic rotation of crops, more care in the selection of seed, increase of live stock, and in later years to the introduction of commercial fertilizers—guano from Peru, nitrate from Chile, phosphate from the United States, potash from Germany; but how much is due to each of these factors can not be determined by any available records.

Fertility of Soils Can Be Temporarily Impaired.—While in the foregoing it has been shown that soils do not wear out in the sense that we have been accustomed to use this term and that there is no general deterioration of lands, the individual can abuse his soil as he can abuse his own physical powers, but in the long run, even in the finite time with which we are concerned, it does not affect the great problem of the general fertility of the soil. It is but a detail making up the general average of national soil conditions.

The fertility of the farm can be temporarily impaired by improper or careless cultivation, as in the case of cotton soils of the South, where erosion is so rapid that the planter can hardly maintain from year to year the soils that he last year cultivated. And what becomes of the soil that is eroded? It forms the fertile rice lands of the deltas of the rivers. These are the soils from the poor washed lands of the upcountry changed as to their organic matter content, which they have acquired in their gradual progress down the streams, and changed as a result of this organic content in their physical properties, but unchanged with respect to the kind of minerals they contain. They are not and never have been exhausted of plant food. With this change of state they are wonderfully productive. The fertility of the soils can also be temporarily impaired by improper rotation of crops as has already been shown.

Most soils deteriorate through neglect and insufficient and injudicious cultivation. It is a general experience that soils deteriorate under tenant farmers, who have little interest in the welfare of the farm beyond the year of certain occupation and little capital and insufficient stock to work it with. Such cases are seen in almost all communities, where individual farms or even settlements have deteriorated, while the surrounding fields under better management maintain their fertility.

Soils also deteriorate even with fairly good treatment when continuously cultivated in one crop, whether it be cotton, wheat, corn, or tobacco. There are soils like the Marshall soils of the prairie regions and the Houston and Yazoo soils of the South which appear to be notable exceptions to this, but we of the United States are beginning to realize very generally, what older countries have known for generations, that it is neither safe nor judicious to have a one-crop system on any of our fields, or at least that such a system should not be continued long with annual crops.

Certain soils deteriorate quickly through natural but obscure causes, even with the best attention to cultivation. Some of the reclaimed muck soils of Illinois and Wisconsin produce one or two large crops of corn and then produce little or no yields unless the soil is heavily manured or treated with a potash fertilizer. Some of the reclaimed muck soils of California yield one or two large crops of potatoes and then fail completely to produce a third successive crop, although the power to produce barley is unimpaired. Flax is considered one of the most exhaustive crops, as but two or three successive crops can be taken from the same land, although wheat will produce normal crops after the flax fails. Again, in forcing vegetables and flowers in greenhouse work the soil quickly becomes unable to support the continuous growth of a certain plant, in spite of the liberal use of manure and fertilizers, although it may still be just as well adapted to different kinds of crops.

Soils, of course, frequently deteriorate through erosion where the top soil is removed, leaving the infertile subsoil as the medium of growth. Examples of this are frequently seen in the Cecil soils of the Piedmont Plateau.

HOW FERTILITY IS MAINTAINED.

The maintaining of the productiveness of a soil means that there shall be preserved within the soil sufficient quantities of soluble plant food of the various kinds to produce maximum crops. To do this it is not only necessary to maintain a large humus supply but the soil must be kept in a good physical condition and if it is to remain permanently fertile the total supplies of the various elements must be maintained. We should therefore distinguish between what might be termed a temporary system of agriculture in which the available plant food gradually decreases, and a permanent system of agriculture or that in which the available food shall be indefinitely maintained. The latter point of view is the proper one for the man who owns a farm of fair size, free of indebtedness. The former may be better for the renter or the man who is just beginning and who must pay for his land as well as support a family. It is perfectly proper for a man to farm land hard until he gets started if this is necessary, but he should not form the habit; and just as soon as possible he should begin building up his land again so as to put it into as good or better condition than he found it. The man with the greatest knowledge and business ability can pay for land and build it up at the same time, providing misfortune does not befall him.

Since humus may be so rapidly removed from a soil by exhaustive cropping it is highly important that a means be provided for replacing it. The first essential to the maintaining of the humus is the adoption of a crop rotation which shall include legume crops. Even a small grain alternated with corn will maintain the humus much longer than where corn is grown continuously, and where a legume crop such as clover is introduced, the supply of humus is much better maintained.

Improper methods of tillage add very greatly to the evil effects that result from lack of humus. In many parts of the country the land is plowed only 3 or 4 inches deep. Below the plowed stratum the soil becomes sour, densely packed, and unfit for plant roots. When such soils are plowed deep and this sour packed subsoil is mixed with the upper portion, the growth of many crops is greatly retarded This has led many farmers to believe that deep plowing is ruinous. Some farmers have tried to remedy the difficulty by subsoiling. The subsoil plow breaks up the packed layer but does not throw it out on top. But while subsoiling does break up the hard layer into chunks it does not pulverize it or put humus into it. In most cases work done in subsoiling is practically wasted, and it is doubtful if it ever pays. A much better method is to plow a little deeper each year until a depth of 8 or 10 inches is reached. This gives a deep layer of good soil, particularly if the supply of humus is kept up.

When new soil, or that which has lain undisturbed for several years, is broken up, it is always best to plow deep from the beginning, for the deeper layers will be about as fertile as any, except the top inch or two. It is wise never to plow the same depth twice in succession. In general, fall plowing should be from 7 to 9 or 10 inches and spring plowing from 5 to 7 inches deep. There are special cases in which these rules do not apply.

We plow the soil in order to loosen up its texture and get air into it; also to turn under stubble, manure, etc., to make humus. Killing weeds is another object accomplished by plowing. After a soil has been thoroughly pulverized to great depths, so that there is no danger of turning up packed clay, the deeper the plowing the better the crops. But the cost also increases with depth, so that ordinarily it does not pay to plow more than about 10 inches deep.

Some crops prefer rather a loose seed bed. Millet is such a crop. Farmers sometimes plow a second time in order to sow millet on freshly plowed land. Other crops, such as wheat and alfalfa, prefer a fairly compact seed bed; hence, frequent harrowing and rolling after plowing is good practice before seeding to these crops. Nevertheless, it pays to plow the land for them, even if we have to compact it again before seeding. The plowing aerates the soil and helps to set plant food free.

The poverty of the soil may be due to poor texture, unfavorable structure, lack of humus, deficiencies in the amount, form, or proportion of plant food, and to the presence of harmful mineral and organic compounds. With the exception of nitrogen, most soils, even those that are very poor, usually contain an abundant supply of plant food, though sometimes other elements are lacking, or are present only in those forms that plants cannot use. To increase fertility the texture must be improved, and plant food and humus added. Tillage will do much to improve the texture, but will not suffice alone. It will not add humus.

In improving a loam soil which is raw and unproductive, put on a light top dressing of well-rotted manure and turn it under about 3 or 4 inches deep. Let this stand four weeks to ferment, then turn it over about 2 inches deeper; then plant a crop—rye or cowpeas if the soil is very poor. With such treatment the soil will gradually darken throughout, although it may take two or three years to bring it up to a fair state of fertility. The change in condition will be evident to the eye. Each type of soil will, however, require somewhat different treatment, and the method of cultivation adapted to one soil will not perhaps be suited to another. Judgment and experience is required in the cultivation of an infertile soil with a view to improving it, even more than in maintaining the fertility of a productive soil.

The improvement of an infertile soil or the changing of a raw subsoil into a true soil involves a fermentation of organic matter to produce other and more stable compounds, just as in the fermentation of tobacco to produce quality in the leaf, the fermentation of malt, the ripening of cheese and of fruits, and the "raising" of bread. Cigar tobacco will not develop aroma by hanging in a barn in contact with air. It must be put into a bulk, built neither too compactly nor too loosely, and the amount of moisture, temperature, and aeration must be carefully regulated, with respect to the peculiar character of the leaf and the purposes for which it is intended, to get the best results. So in the proper fermentation of the organic matter of the soils we must study more the laws and conditions of fermentation, and we must realize that this is greatly aided by enzymes and plant life itself, either by the lower bacterial forms or by the higher forms—the crops and even the weeds and other native vegetation.

After cultivation the most important thing is the selection of the proper crop, even of the proper variety of any particular crop and the proper rotation of the selected varieties. This will undoubtedly aid in improving the soil, and more often still it will prevent soil deterioration. No exact or thoroughly satisfactory system of crop rotation has yet been worked out for any particular soil. After cultivation and rotation, fertilization is an important and powerful factor in soil improvement. We have then, proper drainage, cultivation, aeration, rotation, and fertilization, all acting to the same end, namely, the maintenance of sanitary conditions in the soil to increase the productivity of worn-out lands.—(F. Bs. 87, 245, 257, 406; Y. B. 1909; Cornell R. C. Soils Series 5; Bu. of Soils B. 55; Purdue Univ. Bs. 57, 95; Clemson Col. B. 32; Univ. Wis. B. 139; Univ. Wyo. B. 82; Colo. Agr. Col. B. 65; Univ. Ill. B. 82; Cornell Univ. B. 174; Univ. Mo. B. 38.)

EFFECT OF ORGANIC MATTER ON SOILS.

Soils have been variously classified as regards their differing qualities and composition. The following is the classification most generally accepted:

Sand.—Soils consisting almost exclusively of sand.

Sandy Loams.—Soils containing some humus and clay, but an excess of sand.

Loams.—Soils inclining neither to sand nor clay, and containing some considerable portions of vegetable mold, being very pulverulent and easily broken up into loose and porous masses.

Clays.—Stiff soils in which the silicate of alumina and other fine mineral particles are present in large quantity.

Marls.—Deposits containing an unusual proportion of carbonate of lime, with often some potash or phosphoric acid resulting from the remains of sea animals and plants.

Alkaline.—Soils containing carbonate and sulphate of soda, or an excess of those alkaline and other soluble mineral substances.

Adobe.—A fine grain porous earth of peculiar properties.

Vegetable.—Soils containing much vegetable debris in an advanced state of decomposition. When such matter predominates, or exists in large proportion in a soil, the term tule, peat or muck is applied to it.

Geest.—Soil resulting from the gradual decay of the original rocks.

Alluvium.—Soil deposited by streams.

Loess.—Wind made soil.

Till.—Soil left by melting glaciers.

Some soils are crumbly or mellow, and when plowed the furrow slice turns over loose and granular; while in others, especially silty or clayey soils, the plowed ground is likely to be cloddy, and heavy rain causes the soil to run together and bake when dry. The one is in good tilth while the other is not. If the crumbly soil is examined it will be found to be made up of crumbs or granules from the size of timothy seed to that of peas, formed by loosely cementing a number of soil particles or a number of smaller granules together. These crumbs vary in size in different soils, and even in the same soil at different seasons. This texture of peculiar granular condition is brought about by natural causes acting upon certain constituents of the soil and not by tillage, although tillage helps to bring about the condition sooner, as when cloddy ground is harrowed after a shower. The moisture develops a friable condition, and the use of the harrow simply hastens the work of nature. Without the shower it would have been almost impossible to get the ground into good shape.

This granulation or crumbly condition is a necessary property for silt and clay soils. A handful of dust from the road looks and feels quite different from a handful of dry mellow soil from a well-managed field. The former is made up largely of incoherent soil particles, while the latter is made up of granules or crumbs of various sizes. Black clay loam, frequently called gumbo, the soil commonly found in low, flat prairies in central Illinois, usually exhibits this property, while the brown silt loam of the rolling prairie shows it to a less extent. The heavy clay soils of the river bottoms sometimes go under the name of buckshot land because of their granular character. This property of granulation gives to a soil some of the advantages of a sandy soil without its disadvantages, in that it makes it easier to work and keep in good tilth, while it retains moisture and plant food well. The size of these granules varies with the soil and the length of time of exposure to the elements. They are larger in spring than later in the season. The summer and fall rains frequently almost destroy them, and it may require a winter's freezing and thawing to develop them again. It is generally recognized that the soil is in better condition for plowing after a cold winter, and this is undoubtedly due to the granular character developed by freezing. A cold winter may not be sufficient to restore this condition after a very wet summer.

The complaint is often made that soils run together and bake after every heavy rain. This is often true of fine-grained silty or clayey soils, but not of sandy ones. It is due to the breaking up of the soil granules into their individual particles by the beating of the rain drops, and this produces a puddled condition of the surface which, when dry, forms a hard crust through which the young plants can pass or force their way only with great difficulty. The crust being somewhat impervious to air, the growth of the crop may be hindered by lack of aeration. The roots of growing plants require oxygen, as do also the bacteria of the soil that carry on the process of nitrification, producing nitrates for plant growth. A crust on the surface when corn is young soon causes it to become yellow, indicating a lack of nitrogen, probably due to the fact that nitrifying bacteria are unable to carry on their work properly for want of oxygen. A crust also causes a loss of moisture by increasing evaporation, the soil having been so compacted by the rain that the soil particles have been brought into close contact with each other and continuous capillary connection has been established, so that the water now may pass rapidly to the surface, where it is evaporated.

Running together may be largely prevented by increasing the amount of organic matter. This cements the soil particles together into granules, holding them so firmly that only the hardest rains break them down, and furnish the puddled condition necessary for the formation of a crust. Every one has seen the effect of an old strawstack or manure heap on the soil. Places where these have been are always mellow when cultivated, because of the organic matter contained in them. Every soil should contain enough organic matter so that it will not run together except with the heaviest rains, and even then not so as to interfere seriously with the ordinary physical phenomena of the soil.

Wherever land is not level and the rainfall is greater than can be absorbed, more or less washing occurs. The amount depends upon the physical composition and texture of the soil, the extent and slope of the surface, the presence or absence of vegetation, and the character and amount of the rainfall.

A very gravelly or sandy soil that allows the water to pass downward readily is not likely to wash badly, for the reason that very little water runs off by surface drainage even on a considerable slope. If, however, the soil is a silty or clayey one, it will absorb water very slowly, and a large amount will run off and carry with it the best soil. Silt and clay soils are much more liable to wash than sandy ones. While it is impossible to change the inorganic constituents of soils to any appreciable extent, yet they may be treated in such a way as to change the texture in a few years. This may be done by incorporating organic matter in them. The partly decayed material cements the soil particles into granules, and thus checks washing.

It is a well-known principle that dark surfaces absorb the sun's heat, while white surfaces reflect it. As a rule the more organic matter a soil contains the darker it is, and this makes it a good absorber of heat. Consequently dark or black soils become warmer than those of the same physical composition but lighter in color. This difference in temperature noticeably affects the germination and growth of plants. The difference between times of germination on light and dark soils is a matter of common observation. In spring when corn begins to come up the rows may be seen sooner upon the low, black soil than upon the higher, lighter colored soils, provided the conditions of moisture are about the same for each. This is usually attributed to the fact that the black soil is the richer, but the amount of plant food in the soil has very little to do with the growth of corn up to the time when it may be seen in rows. It will reach this stage in pure sand devoid of any plant food.—(Univ. Ill. B. 82, 119; Fla. E. S. B. 48; Iowa Col. B. 82.)

TREATMENT OF MUCK SOILS.

Muck soils are widely distributed, in small or large areas, in the United States. When properly drained and handled they are in many cases extremely productive. The amount of muck land reclaimed by drainage and brought under cultivation is rapidly increasing, and it is becoming a matter of considerable importance to know the best methods of utilizing such lands. Extensive areas of muck soils are found in Florida.

It is recognized that proper drainage is a necessary prerequisite to the use of muck soils, for if muck soils are to be cultivated it is obvious that they must first be drained. This is necessary in order that they may become the home of the various kinds of micro-organisms that play an important part in the making of a fertile soil. These micro-organisms need moisture, but they can not develop in mud or standing water. The method of cultivation requires particular attention.

Cultivation should be deep, especially at first, in order that the air may thoroughly penetrate the soil. Muck soils often contain substances that are injurious and even poisonous to plants. When these poisonous substances are exposed to the air they are probably oxidized to a considerable extent and thus destroyed. A free circulation of the air also improves the conditions for the development of the useful micro-organisms.

The great value of these soils when properly reclaimed has led European farmers and investigators to devote much attention to their utilization, and increased attention is being directed to the same subject in this country. The salt marshes, especially along the New England coast, have been extensively used for many years for the production of forage, and in many cases expensive and elaborate systems of reclamation have been carried out on them. Reclaimed swamp or muck soils are being extensively utilized in Michigan, Ohio, and other regions for the production of celery and onions, for which they seem to be peculiarly adapted.

While conditions vary considerably in different cases and each soil may present some peculiar conditions of its own, the general principles and practices are the same for all this class of soils. Thorough drainage is the first essential. This is not only necessary for the purpose of removing the excess of water, but to allow the free circulation of air in the soil, in order that the poisonous compounds which are usually present may be oxidized and thus rendered harmless, and that the processes of decomposition and nitrification so necessary in this class of soil may be set up.

The drainage is best accomplished at first by means of open ditches at frequent intervals. Muck soils settle greatly when drained, and if tiles are laid in the soft muck they will rise toward the surface, and thus become ineffective. Draining is most effective when carried out gradually, and the soil should not be allowed to dry out too quickly, since its mechanical condition may be thus injuriously affected, its absorptive power for water in many cases almost completely destroyed, and the decomposition of the organic matter greatly retarded. After the soil has become firm tiles may be laid, especially if collars are used.

It is frequently found that muck soils, even after the most careful drainage, are still unproductive. The fertilizing matter which they contain is in unavailable condition for plants. A common practice in Ireland and in European countries is to pare the surface and after drying to burn the organic matter. This practice of burning has been condemned as exhausting to the soil, but without good reason.

The first object sought in fertilizing should be to correct the acidity of the soil and to set up the processes of decomposition of the organic matter and nitrification, so as to convert the inert into available plant food. Liberal applications of decomposing manures, such as barnyard manure, in connection with dressings of lime have usually been found effective for this purpose. Lime and the bulky manures exert a beneficial effect on the texture of the soils, rendering them more porous, and thus improving drainage and increasing aeration and nitrification. Liberal applications of wood ashes also improve the texture of the soil, correct acidity, and favor nitrification, and at the same time furnish potash and phosphoric acid, which are likely to be deficient. The by-product from steel manufacture, known as Thomas slag, is used with good results on such soils in Europe. It is rich in lime and thus effective in correcting acidity and promoting nitrification, and it also supplies phosphoric acid. It is generally applied in the fall in connection with some potash salt such as kainit or muriate of potash. It is doubtful, however, whether this slag can be obtained at present in the United States at a price sufficiently low to justify its use for this purpose. A dressing of lime (30 to 40 bushels per acre), followed by an application of a mixture of kainit or muriate of potash with some cheap phosphate, such as fine-ground Florida phosphate, may be substituted for the slag mixture. The untreated mineral phosphates have been used with advantage on muck soils, the decomposing organic matter assisting in rendering the phosphoric acid available.

Covering bogs with a layer of sand or gravel 4 to 6 inches thick has been successfully practiced in Ireland and European countries, but it is doubtful whether this method is generally applicable in the United States.

Oats, potatoes, and buckwheat have been found to thrive better than wheat or clover on recently reclaimed bogs. The grasses generally have been successfully grown on such soils, and, as already stated, they seem to be well adapted to celery and onions and are extensively used for the growth of these crops. In Europe sugar beets are grown with good results on such soils.—(F. B. 78; F. B. 366; Fla. E. S. B. 93; Press B. 100.)

THE NEEDS OF MARSH SOILS.

When compared with upland clay loam or sandy loam soils, marsh soils are found to differ from them in several important ways, both physically and chemically. Physically, they lack drainage and are usually cold and in their undrained condition are subject to frosts. The peat marsh soils are often too loose to form a good seed bed for many crops. Chemically, they are characterized by excessive amounts of vegetable matter and often are deficient in mineral elements.

Marsh soils have certain drawbacks, but also some important advantages as compared with upland soils. When they occur in considerable areas they are more easily cleared than cut-over timber land and, being free from stone, can be brought under cultivation at much less expense than the upland soils, even though drainage is necessary. For this reason the marsh lands should be developed as soon as possible and used for producing pasture and hay for winter feed.

While marsh lands all need drainage and are excessively rich in organic matter, they differ radically from each other in several respects, and it is important that these differences be distinctly recognized. Many marshes will prove highly productive while others are of very much less value. On account of these differences marsh soils require different treatments, and it is of the utmost importance that persons operating such lands understand their character as fully as possible. The most important factors to be considered in the management of marsh soils are: (1) drainage, (2) preparation of seed bed, (3) use of manure and other fertilizers, and (4) the selection of the proper crops to be grown.

The first step in the development of any marsh land is to drain it. In the case of large areas this will require the construction of large main ditches, requiring the use of a dredge, and co-operation among the adjoining owners, either by organizing a drainage district or by having the town or county officers take charge of the work. In the case of smaller areas this can frequently be done by mutual agreement between two or three adjoining owners.

Two kinds of drainage must be provided for—first, surface drainage, and second, subsurface drainage. It is occasionally true that the construction of ditches around the edge of a marsh tract in such a way as to carry off most of the water from the surrounding higher land without letting it onto the marsh will reduce the wetness of the marshland to such an extent that crops can be grown without further ditching. Ordinarily, however, ditches on the marsh itself are necessary.

The necessity for subdrainage either by deep open ditches or tile depends very largely upon the character of the subsoil and its relation to the surrounding land. When subdrainage is necessary, the use of tile makes it possible to do away with open surface ditches and so greatly facilitate the operations of cultivation. Nevertheless, the muck and peat of marshlands usually shrink and settle considerably on drainage, making it often desirable to leave open ditches for three or four years until this shrinking has taken place, after which the ditches may be cleaned out and tile laid and covered.

On some marshes, particularly those covering considerable areas where the marsh soil is coarse fibrous peat and underlaid at relatively shallow depths by coarse sand, it is possible that too thorough drainage may occur, so that crops on such land during very dry seasons may suffer from lack of water. Under such conditions it is quite probable that the use of dams at intervals in the mains and larger lateral ditches for holding back the water during very dry seasons will be found advantageous.

Where a deep growth of sphagnum moss occurs it is usually difficult or impossible to plow properly before this has been removed, and the only practical method for this purpose seems to be that of burning.

While it is ordinarily not considered desirable to burn soils more than is absolutely necessary, in such cases as this it can not be avoided, and there is much less objection to burning on marsh lands than on uplands, provided only so much of the surface is burned as is necessary to permit of good breaking. Indeed, the ash from this shallow surface burning adds greatly to the fertility of these lands for the first few years. Where the moss has considerable depth and on boggy marshes it can only be burned during a dry season and in the hot summer period of July and August. Great care must, of course, be used to prevent the spread of fire under such conditions.

Whether burning is necessary or not, the summer and early fall is the best time for the plowing of such lands. Where the soil is of a mucky character a good stubble plow can ordinarily be used successfully. Where, however, the soil is peaty, a good breaking plow with very long mold board must be used, and the larger the plow the more successfully can the furrow slice be turned. For this reason the use of a large steam plow on such lands is very successful.

Moreover, the great weight of such a plow is extremely beneficial to pack the soil so as to secure a firmer seed bed. This compacting of the peaty soil doubtless hastens its rotting and the necessary chemical decomposition to produce fertility, while it also firms the soil, thus greatly improving its texture as a seed bed, especially for cereals. These crops ordinarily do best on rather close soil, such as clay or clay loam, and the more nearly marsh soils can be brought into that condition the better will they be adapted to their culture.

In chemical composition, marsh lands differ from upland soils chiefly in having a very large amount of nitrogen, due to their high content of organic matter and usually a relatively smaller amount of the other essential plant food elements, phosphorus and potassium. When marsh soils occur in a limestone region, such as that in the eastern and southeastern part of Wisconsin, the lime from the subsoil and rock of the regions surrounding the marsh is dissolved out by the waters percolating through the soil and carried to the marsh so that these marshes are usually well supplied with lime and are not acid.—(Wis. E. S. B. 205; F. B. 78; F. B. 320; F. B. 465.)

ACID SOILS.

The breaking down of organic matter in the soil is accompanied by the formation of various organic compounds. The exact nature of these compounds is not well known, though it is generally agreed that certain organic acids are among the products. These organic acids have been variously spoken of as humic, ulmic, crenic, and apocrenic. Some writers have questioned the existence of such acids, but it is very certain that the water extract of certain soils, especially muck soils, does have a decidedly acid reaction, even after it has been thoroughly boiled; and since muck soils are made up almost entirely of organic matter, it would seem safe to assume that acids result from the breaking down of the organic matter, at least until this has been disproved.

There are two principal effects produced by using lime on soils: One of these is to correct the acidity of the soil, and the other is to decompose the soil itself. To correct the acidity of sour soils is certainly a very desirable and profitable use of lime. Clover, alfalfa, alsike, cowpeas, soy beans, and many other legumes will not live or will not thrive to the best advantage on soils which are strongly acid. To be sure such crops can be made to grow on acid soils by liberal applications of farm manure or other complete fertilizers but the nitrogen gathering bacteria of the legume plants do not properly develop and multiply in acid soils and consequently the legumes do not have the power which they should have to accumulate large quantities of atmospheric nitrogen by means of the bacteria which inhabit, or should inhabit, their roots. Furthermore, the process which is termed nitrification by which the nitrifying bacteria transform the insoluble organic nitrogen in farm manure and plant residues into soluble nitrate nitrogen, the form in which it becomes available as plant food, is greatly promoted by the presence of lime and retarded by acid conditions.

It will thus be seen that the use of some form of lime for correcting the acidity of soils and thus encouraging the growth of clover and other legumes with their wonderful power to enrich the soil in nitrogen is certainly good farm practice. Any form of lime which is finely divided and can be thoroughly mixed with the soil will serve to correct the soil acidity, whether it be ground limestone, marl, or chalk, or fresh burned lime, water-slaked lime, or air-slaked lime.

The other effect produced by lime, the effect for which it has been most used in past ages, is the decomposition of the soil itself. In this decomposition the organic matter of the soil is destroyed with the liberation of nitrogen and phosphorus held in organic form and the mineral particles of the soil are disintegrated with the liberation of some plant food elements, as potassium and phosphorus held in inorganic form. This effect is produced by fresh-burned lime or fresh slaked lime.

Thus it will be seen that the first effect of lime, the correction of soil acidity, results in a building-up process through the increased growth of legumes and nitrogen-gathering bacteria; while the second effect, the decomposition of the soil, is in all respects a destructive process, serving only to liberate and reduce the stock of plant food stored in the soil. Whether this second effect is desirable will depend upon the nature of the soil itself.

For the benefit of those who may desire to employ lime, a few practical suggestions about liming may not be out of place.

First.—Sandy soils should not be limed heavily. For such soils carbonate of lime and wood ashes are to be preferred. If slaked lime is to be used upon such soils, that which has been long exposed to the air is best. Half a ton to a ton of slaked lime per acre or twice that quantity of either ground limestone or wood ashes may be used in a single application.

Second.—For very heavy clay soils, or such as are rich in sour humus, twice as large amounts of lime may be used as for sandy soils. For use upon such soils pulverized burned lime or water-slaked lime may sometimes be preferable to finely ground limestone or wood ashes.

Third.—To make liming immediately effective, the material should be spread upon the furrows and be harrowed into the soil most thoroughly. When applied in grain drills its benefits are often not strikingly noticeable the first year, owing to the fact that it does not become intimately mixed with the soil until after the first season.

Fourth.—After being sown, the lime should not lie upon the surface over night or during a storm, but it should be introduced into the soil at once If potatoes are grown in rotations, the liming should follow the removal of the potato crop. One exception to this might be made if potatoes must be grown at the outset when one is taking up acid-exhausted soil. In such a case it is often better to lime before planting the first crop, though in later years liming should be deferred until after the potatoes are harvested. In no case should treatment of the seed tubers with corrosive sublimate solution (1 to 1,000) or formalin be omitted, or serious injury from potato scab will be likely to result.

Fifth.—In liming in the course of a rotation, applications at intervals of from five to six years are usually sufficient. The lime should, if possible, be applied just before a crop which is especially likely to be helped by it, and the more indifferent crops may be introduced later.

Sixth.—The lime may be slaked in small piles in the field or in larger piles at one side, or it may be air-slaked in a water-tight building, so that there may be no danger of fire. In the case of small piles, some moist soil thrown over the lime facilitates slaking. Sprinkling the burned lime with the proper amount of water will make it slake quickly to a powder.

Seventh.—Magnesian lime may sometimes be used to advantage in place of pure lime, but it should not be used repeatedly on the same land.—(Bu. of Chem. B. 30; Fla. E. S. B. 83; An. Rpt. Del. E. S. 1899; Ore. E. S. B. 90; Univ. Ill. B. 110; Fla. E. S. B. 93; Of. Ex. Sta. F. I. Lecture 3; F. B. 77.)

TREATMENT OF ALKALI SOILS.

Many ways of handling alkali soils have been tried in the past with varying results. Remedies quite successful in one locality have proven utter failures when tried in other districts. It is well to state at first that no chemical means of treating white alkali has proved economical or practical.

Drainage.—As poor drainage is usually one of the direct causes of alkali, the first step in treatment is to supply the best possible drainage. The high cost of tile drainage eliminates this method at present, but a few open ditches will often remove the surface water in the spring and prevent it from collecting in these low places.

Cultivation.—After the best possible drainage has been secured, heavy application of strawy horse manure should be made at the rate of from fifteen to twenty tons per acre during the summer or early fall. The manure has three beneficial effects, first, it makes the soil more open and porous, allowing better drainage, preventing both puddling and baking; second, it will act somewhat like a mulch, preventing surface evaporation and gathering of the salts at the surface; third, it will supply the young plant with available plant food in the spring, when the alkali soil, which is inclined to be cold and dead, will not. Plow the land in the summer as deep as the subsoil will permit. This will leave the soil open and exposed to the snow and frost during the winter, which will tend to sweeten it for the following year, as fall plowing always tends to do. In the spring, as soon as the land is dry enough to permit, surface cultivation either with the cultivator, disc or spike tooth harrow should be followed. This will prevent surface evaporation and form the best possible seed bed for the crop. Thorough cultivation must always be maintained upon alkali soil in the spring before the crop is seeded.

Crops.—Next comes the question, what crop is to be tried upon such soil? Experiments have proved conclusively that plants differ widely in their ability to withstand alkali. What is wanted is a crop that will aid in removing the salts and at the same time give a profitable return. Of the cultivated crops, sugar beets will stand the most alkali and give good returns. They are an inter-tillage crop, being cultivated between the rows like corn, thus keeping a surface mulch on the ground. They also absorb large amounts of soluble salts, and remove the salts in this way. Sometimes the first crop on such soil will absorb such a large amount of salt that cattle will refuse to eat the beets, and if starved until they do eat them, the effect is the same as a physic.

The Danish sugar beet is a good variety, and will yield from 400 to 500 bushels per acre. The roots should be pulled in the fall before the frost and the tops cut off not too short. They make an excellent succulent winter feed for all classes of live stock and especially for dairy cattle.

The seeding can be done by using the common grain drill, mixing one-third seed with two-thirds barley chop, stopping up the tubes in the drill to make the rows the required distance apart and regulating the drill to plant the seed at the required rate in the rows. The crop should receive three or four surface cultivations during the summer to keep down the weeds and prevent evaporation. It is sometimes necessary to raise a beet crop the second year on bad spots, but usually it is well to plow in the fall just after harvesting the crop of beets and try a grain crop the following year.—(Manitoba Ag. Col. B. 7; Bu. of Soils B. 10, 12.)

SOIL NOTES.

Sedentary soils, or soils in place, are those which have not been transported by geological agencies, but which remain where they were formed, covering, or contiguous to, the rocks from whose disintegration they originated. They are usually shallow soils.

Transported soils are those which have been removed to a distance from the rock beds from which they originated by the action of moving ice (glaciers) or water (rivers) and deposited as sediment in their present positions.

Drift soils consist of fragments whose edges, at least, have been rounded by friction, if the fragments themselves are not altogether destitute of angles. They are usually deposited without any stratification or separation of parts. The materials consist of soil proper mingled with stones of all sizes from sand grains to immense rock-masses of many tons in weight. This kind of soil is readily distinguished from all others by the presence of the rounded rocks or boulders (hard heads) it contains, and which are promiscuously scattered through it. The drift has undoubtedly been formed by moving ice in that period of the earth's history known as the glacial epoch, a period when the present surface of the country was covered to a great depth by fields of ice.

Alluvial soils consist of worn and rounded materials which have been transported by the agency of running water (rivers and tides). Since small and light particles are more readily sustained in a current of water than heavy masses, alluvium is always more or

A Type of Culvert to Be Avoided. Dept. of Agr.
(See pages 149-165.)

A Better Type of Culvert. Dept. of Agr.

less stratified or arranged in distinct layers; stones or gravel at the bottom, and nearest the source of movement, finer stones, or finer gravel above and further down in the path of flow, sand and impalpable matters at the surface and at the point where the stream, before turbid from suspended matter, finally clears itself by a broad level course and slow progress.

Alluvial deposits have been formed in all periods of the earth's history. Water trickling down a granite slope carries forward the kaolinite (a compound of silica and alumina hydrated, or containing water) arising from the decomposition of feldspar, and the first hollow gradually fills up with a bed of clay. Thus, in the valleys are deposited the gravel, sand and rock dust brought from the neighboring mountain. Lakes and other bodies of water become filled with silt, carried into them by streams.

Colluvial soils are those which, while consisting partly of drift or alluvium, also contain sharp, angular fragments of rock, from which they originally came, thus showing that they have been transported to any distance, but are made up of soils in place more or less mingled with alluvium.

MINERAL SUBSTANCES PRESENT IN SOILS.

Silica, iron, alumina, lime, magnesia, soda, potash, phosphoric acid, sulphuric acid, chlorine, and sometimes manganese and flourine, are present in all soils in varying proportions.

Silica.—Forms the basis of most soils and is by far the most abundant solid constituent of the earth. It is present in soils in proportions varying from 29 per cent to 90 per cent, according to the character of the soil. In its usual insoluble form its action is merely mechanical. In most fertile soils a small amount of it is found in a soluble state, and as such it may enter the sap circulation of plants.

Iron.—Occurs in all soils as a finely diffused ferric hydrate. Its percentage varies from 1.50 per cent to 20 per cent, and it gives the color to red and yellowish soils. Though required in minute quantities, it is absolutely indispensable to plant life. Its function seems to be giving the soil an increased power to absorb and retain heat and moisture, and rendering tillage easier in clay lands. As a plant food it is supposed to aid in producing the chlorophyll, which gives the green color to plants.

Alumina.—The chief constituent of common clay. It does not directly contribute to the growth of plants, and is of but little value as a plant food. As clay, however, it is an essential constituent of soil; it has the property of absorbing and retaining (fixation), the easily soluble compounds of the soil, or those supplied to the soil by fertilization. Alumina varies in amount from one per cent to ten per cent, according to the kind of soil.

Calcium (lime.)—An absolutely indispensable plant food, yet, more important on account of its influence upon the mechanical condition of the soil, in the process of nitrification, and in the formation of soluble carbonates. It is one of the prime essentials of an arable soil; its absence in sufficient proportions is always followed by sterility. Lime is one of the most variable of soil constituents, existing in all proportions, from mere traces to as high as 30 per cent.

Magnesia.—Resembles lime in many respects, and generally accompanies it, as in dolomite or magnesian limestone, present in all cultivated soils. There is abundant evidence that it is needed for the complete development of our more common cereals. Its exact function as a plant food is unknown.

Potassium.—Found in all soils and results from a decomposition of feldspathic rocks. It is an essential constituent of all plant food. As it occurs in soil it is very soluble, consequently is liable to loss through leaching. Ashes of plants contain potash in the proportion of from 10 per cent to 15 per cent.

Sodium.—Is the basis of common salt and as such is everywhere abundant. It resembles potassium, but can in no sense take the place of potassium in plant nutrition, i. e., in land plants.

Phosphoric Acid.—Occurs in all fertile soils, but usually in much smaller amounts than the other important ingredients. Never found free, but always combined either with iron, alumina, or lime. It is one of the soil ingredients most likely to be exhausted.

Sulphuric Acid.—Is one of the constituents of most soils, present in minute quantities, usually combined with calcium in the form of gypsum.

Chlorine.—Is usually associated with sodium in the form of common salt, which occurs in all soils and in natural waters. While chlorine is not a large constituent of soil, nor does it perform a very important part in the soil's work, yet it is found uniformly in plant ash, and is regarded as being in some way essential.

PLANT FOOD REQUIRED BY CROPS.

It should be remembered that of the ten different chemical elements required for the growth of agricultural plants, three come directly from air and water in practically unlimited amounts (except in time of drouth), and that these three, carbon, hydrogen, and oxygen, constitute, as a rule, about 95 per cent of the mature crop. Nevertheless each of the seven elements obtained from the soil, though aggregating only 5 per cent, is just as necessary to the life and full development of the plant, as are these three.

The two elements, sulphur and iron, are required by crops in such small amounts and are present in nearly all soils in such large amounts that the supply rarely if ever becomes depleted, thus narrowing the problem essentially to five elements, constituting not more than 4 per cent of the average crop.

The productive capacity of practically all soils in good physical condition is measured by the available supply of limestone and the three elements, phosphorus, potassium, and nitrogen, because they are required by all crops in very considerable quantities, while in most soils the supply of one or more of them is limited. If the supply of one of these elements is too limited, it must as a consequence, limit the yield of the crop, even though all other factors essential to crop production are well provided. It is because of these facts that limestone and phosphorus, potassium and nitrogen, in commercial form, have recognized money values.

The following table shows the plant food requirements of the more important crops in the Northern States, giving the approximate maximum amount removable annually.

Produce.		Pounds.		
Kind.	Amount.	Nitrogen.	Phosphorus.	Potassium.
Corn, grain	100 bushels	100	17	19
Corn stover	3 tons	48	6	52
Corn crop		148	23	71
Oats, grain	100 bushels	66	11	16
Oat straw	2½ tons	31	5	52
Oat crop		97	16	68
Wheat, grain	50 bushels	71	12	13
Wheat straw	2½ tons	25	4	45
Wheat crop		96	16	58
Timothy hay	3 tons	72	9	71
Clover seed	4 bushels	7	2	3
Clover hay	4 tons	160	20	120
Cowpea hay	3 tons	130	14	98
Alfalfa hay	8 tons	400	36	192
Apples	600 bushels	47	5	57
Leaves	4 tons	59	7	47
Wood growth	1/50 tree	6	2	5
Total crop		112	14	109
Potatoes	300 bushels	63	13	90
Sugar beets	20 tons	100	18	157
Fat cattle	1,000 pounds	25	7	1
Fat hogs	1,000 pounds	18	3	1
Milk	10,000 pounds	57	7	12
Butter	500 pounds	1	0.2	0.1

Name of material.	Nitrogen.	Phosphorus.	Potassium.
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	19
Clover hay	40	5	30
Cow pea hay	43	5	33
Alfalfa hay	50	4	24
Dried blood	280		
Sodium nitrate	310		
Ammonium sulfate	400		
Raw bone meal	80	180	
Steamed bone meal	20	250	
Raw rock phosphate		250	
Acid phosphate		125	
Potassium chlorid			850
Potassium sulfate			850
Kainit			200
Wood ashes		10	100

In maintaining the fertility of the soil it is necessary to return to the soil, in some measure, the elements of plant food removed annually by the crops. The table on preceding page shows the approximate comparative fertilizing value of manure, rough feeds and commercial fertilizing materials.

RELATION OF CHEMISTRY TO CROP PRODUCTION.

The investigations made by the Bureau of Soils during the last ten years have shown that the economic distribution of crops is dependent mainly upon the physical characteristics of soils and upon climate. It has been believed that the chemical characteristics of soils have a more or less direct and controlling influence on the yield of a crop on any particular soil; that is to say, where wheat yielded 10 bushels per acre in one field, and in an adjoining field (the soil of which had the same texture, so far as could be determined, although it might be in a better physical condition) 25 or 30 bushels were obtained, this difference in yield would be found to be due to or associated with a difference in the amount of available plant food in the soil of the two fields. It was believed, further, that the better physical condition resulting through loosening up and aerating the soil and exposing it to the weathering influence of the atmosphere by better and more thorough methods of cultivation would in itself prepare a larger amount of readily available food material for the use of crops.

These two subjects, distribution and yield, are both of vital importance to the farmer; but while the yield of crops has been a study for the experimenter and farmer alike throughout historic times, too little attention has been paid by him to the adaptation of particular soils to crops. The yield is today the paramount question with the farmer, and all his energy and resources in the last analysis tend to this end.

The third object mentioned above, the control of the quality of the crop, while beginning to receive more attention in general agriculture, is a subject which has been of importance up to the present only in special lines of agriculture, such, for example, as the production of the different grades of tobacco. It has been given particular attention by the horticulturist in improving the flavor and coloring of fruits and has been studied in the highly developed industry of floriculture in attempts to control the color, perfume, shape, time of maturity, or other desirable quality of flowers. In such specialized agricultural and horticultural industries, where fertilizers are used to control the quality of crops, it is always considered a necessary prerequisite that the soil be put in the most perfect physical condition for the crop. The assumption that the soil is in such perfect physical condition in general field culture can never be safely made.

Plants can and do yield ordinary crops, though growing in media containing very small traces of all of the plant foods, while if the amount of these plant foods is increased a thousand times, as in the case of the alkali soils of the West, where potash, lime, phosphoric acid, and nitrates are frequently found in very large amounts, they are unable to give corresponding increases in the yield. On the contrary, the yield from these arid soils under irrigation is no greater than that obtained from the soils of the humid regions, which contain far less of these mineral plant foods, provided the season in the humid region is just right, or that irrigation be practiced. Yields of wheat as high as 50 or 60 bushels per acre have been recorded in our Eastern States, and, as far as records go, such yields have never been exceeded under irrigation in the arid regions where most favorable moisture conditions are maintained and the soluble salt content of the soils is much greater than in the humid East.

Exhaustive investigation of many types of soil by very accurate methods of analysis, under many conditions of cultivations and of cropping, in areas yielding large crops and in adjoining areas yielding small crops, has shown that there is no obvious relation between the amount of the several nutritive elements in the soil and the yield of crops; that is to say, that no essential chemical difference has been found between the solution produced in a soil yielding a large crop of wheat and that in a soil of the same character in adjoining fields giving much smaller yields. The conclusion logically follows that on the average farm the great controlling factor in the yield of crops is not the amount of plant food in the soil, but is a physical factor the exact nature of which is yet to be determined.

The results of the investigations also seem to indicate that the actual quantity of water a soil can furnish the plant, irrespective of the percentage of water actually present in the soil, has probably a very important influence on the yield. When the supply of water is inadequate to the need of the plant, as the water is a medium for the conveyance of nutritive solutions to the plant, it may well indicate not only a deficiency in the supply of moisture, but also of nutrient material contained in the water. It may be, moreover, that with an insufficient water supply, and consequently an insufficient food supply, fertilizers, by temporarily increasing the concentration of the solution, may increase the food supply of the plant; but as in this case also the obstructive factor is the purely mechanical function of delivering water from the soil to the plant, the problem is one to be handled by physical methods, and can not, in the nature of the case, be solved by chemical methods alone.

Again, while some variations occur in the composition and concentration of the soil solution, in the case of the great majority of cultivable soils these variations are within comparatively narrow limits. The nature of the solution is but seldom permanently affected by the addition of ordinary mineral fertilizers, and it seems safe to say, therefore, that the concentration with respect to the mineral plant food constituents per unit of solution is approximately constant. Considering the wide variations in the percentages of water present in different soils, however, the amounts of dissolved plant foods in them may be quite different.

The conclusion seems justified that, although differences in the dissolved salt content, or in the concentration and composition of the soil moisture, may be a factor in the yield as well as quality of a crop, it does not appear to be a major one in determining or controlling the wide variations observed in crop yields on different soils. It appears further that practically all soils contain sufficient plant food for good crop yield, that this supply will be indefinitely maintained, and that this actual yield of plants adapted to the soil depends mainly, under favorable climatic conditions, upon the cultural methods and suitable crop rotation, a conclusion strictly in accord with the experience of good farm practice in all countries, and that a chemical analysis of a soil, even by these extremely delicate and sensitive methods, will in itself give no indication of the fertility of this soil or of the probable yield of a crop, and it seems probable that this can only be determined, if at all, by physical methods, as it lies in the domain of soil physics.

The Color of Soils.—It is recognized that soil colors are not pure colors, but at best are shades and tints. Thus, the material by which soils ordinarily considered as red are colored is ferric oxide, which is never a pure red, for it varies from dark brown to yellowish, and when in the soil it is further tinted and shaded by other materials.

In soils it is possible to find almost any conceivable color, from the white beach sand to the black mucks of the swamp. Soils generally fall into one of three color groups; white, red and black. Whitish or gray soils are not generally of much agricultural value for general field crops, though sometimes of very great value for special purposes. In humid climates such a color indicates immediately that the soil lacks organic matter. In general it has a very high content of silica and alumina and very small content of iron or other colored oxides and organic matter. In arid regions the so-called alkali sometimes accumulates in white spots, frequently inhibiting the growth of plants. Occasionally a high content of gypsum gives some soils or arid regions a white or light-gray appearance.

Yellowish soils are very common, although a truly yellow soil is rather rare. It is generally considered that they owe their color to small amounts of ferric oxide, more or less hydrated. Black soils are universally esteemed highly. They are characterized by a high percentage of organic matter and frequently a comparatively high percentage of lime. The color is thought to be due to the formation of black humus bodies by the interaction between decaying organic compounds and the lime or other bases in the soil.

In the cotton States red soils are much in favor for agricultural purposes. In the States south of Pennsylvania and east of the Mississippi River there are many occurrences of soils of a bright red color. In the cotton States it is common to find intermingled with these bright red colors, yellow, brown, blue and green in the same bank.

The color of a soil may indicate the presence of a component in itself of actual benefit to the plant. Light-colored clayey soils generally contain goodly amounts of potash, and real black soils contain organic material in abundance. Color may also indicate the manner of formation of a soil, or the parent rock strata from which it was formed.

As a physical property, color can be of direct agricultural value only through the effect that different colors have in radiating and absorbing heat and possibly in regulating light intensity, for many chemical and bacterial reactions are influenced by that factor. The high quality of the wines made from grapes grown on red soils on the hillsides of northern Europe may be due to the greater amount of heat the grapes have had during the growing season.

The dark colored soils absorb the heat of the sun more readily than the light colored soils. Red soils, their color being near the heat end of the spectrum, absorb heat readily. In the early part of the growing season, before the cultivated crops shade the ground, or in the case of crops that do not cover the ground, this variance of heat absorption by different colored soils is a factor of considerable economic importance. Melons have been ripened in a very inclement climate by covering the soil to the depth of one inch with charcoal.

Washing of Soils.—There are large areas of land in the different sections of the country that are being ruined by the washing and gullying of the soils. The amount of washing depends upon the amount of surface run off. The amount of run off and the effect it has, will be modified to a large extent by the character of the soil and subsoil, by the length and steepness of the slope, by the tillage practiced, and by the vegetation produced. Nothing will completely ruin land more quickly than washing, especially gullying.

The washing produced by the run off is of two kinds, sheet-washing or general surface washing, and gullying. In the former the water is spread over a uniformly sloping surface where there is little or no tendency to collect into streams. If the soil and covering are uniform in character, the wearing of the water will be the same for all points. Ordinarily, however, it is not so simple as this. More frequently the gradient is not uniform, the general slope will contain many smaller slopes, the water will collect into streams in the draws and this accumulation of water will give greater volume with less resistance, and consequently the water will attain greater velocity. The washing, or work, that a stream does varies with the velocity of the water and this depends upon four things: the slope, the resistance to movement, the volume of water, and the amount of sediment carried in suspension.

Swift streams have much greater power to wash than slow ones. In general, the transporting power of running water varies as the sixth power of its velocity, or doubling the velocity increases the carrying power 64 times and trebling the velocity increases the carrying power 729 times. Hence it is that gullies form so rapidly on steep slopes and hillsides. Hills are frequently broadly dome shaped with a profile such that the velocity of the water increases toward the brow of the hill, due to an increase, both of slope and volume of water. This gives a skirt or zone of badly-eroded soil while the top of the hill or ridge has suffered comparatively little from washing. The gullies thus formed work their way farther up the hill by what geologists call head erosion until a point is reached where the concentration of the run-off is not sufficient to produce a gully. In some cases the gullies are formed by the receding of small waterfalls. This is especially true where grass is growing in a draw and the gully starts in from below. The fall gradually travels up the draw, the falling water undermining the precipice and causing it to fall in. Gullies formed in this way are usually deep and wide and very difficult to fill.

The amount of organic matter varies quite widely with the type of soil, and it is necessary to increase the amount to an extent that it will cement the small particles of the soil so they cannot easily be washed away.

The effect of organic matter on a soil is to keep it loose and in condition so it will not compact readily and to bind the finer soil particles into granules or crumbs, both of which tend to make the soil more porous. This increase of porosity gives a greater power of absorption and in this way diminishes the amount of surface run-off and lessens the washing. Soils rich in organic matter do not wash badly because the granular structure is developed in them, and these compound particles will not be carried so readily by the water as the individual particles. In soils deficient in organic matter, a heavy rain will so compact them that but little absorption can take place. When the surface of such a soil dries it becomes very hard and forms what is commonly called a "crust." With a fair supply of organic matter in the soil it is not difficult to keep a mulch on the surface for conserving moisture.

The direction of plowing, planting and cultivation is usually determined only by convenience and regardless, too often, of consequences. The farmer should learn to look not only to the present, but also to the future of his soils. Plowing is more frequently done up and down the hill than in any other way. The making of dead furrows in this direction is bad practice. Nature could not desire a better beginning for a gully. The work of one season's run-off may be sufficient to produce a gully that the next season's tillage operations does not fill and the slight draw soon increases and becomes a source of annual trouble. The slopes should be kept as uniform as possible to prevent any accumulation of water in draws.

On land liable to serious washing plowing should always be done along contour lines or across slopes. In the southern states where they have studied the problems of soil washing more than in any other region contour plowing is universal. From Virginia to Arkansas this is the only method practiced on rolling land. The water in running across the furrows meets with more obstructions and greater resistance than in running with the furrows.

Plowing up and down the hill is apt to leave small depressions between furrows in which the water will accumulate and do washing. Planting should be done across the slope.

While the direction of plowing is important the depth is equally so, since this controls in large part the amount of run-off. A deep layer of loose soil will absorb a considerable rainfall without run-off. Five inches of such soil will readily absorb one inch of rainfall. Deep plowing mixes the organic matter with the soil to considerable depth thus keeping it loose so that the water will penetrate it quite rapidly.

In the southern states it is a somewhat common practice to terrace the slopes, the kind of terraces depending upon the character of the soil and subsoil. Where the soil is pervious, such as a sandy soil, the terraces may be run on a level across the slope but more frequently they are given sufficient fall so that the water runs along the terrace without doing much washing. The water is kept on the terrace by an embankment on the lower edge. Hillside ditches are sometimes used to prevent washing. A ditch is run across the slope with a fall sufficient to carry the water off without doing any damage. A number of these are made upon the slope, each one carrying off its share of surplus water. The distance between the ditches is determined by the slope, the steeper the slope the closer the ditches. Sometimes the hillside ditch and terrace are combined, the ditch being placed at the edge of the terrace.

The owner of very rolling or hilly land must be on the lookout constantly for incipient gullies and must use every means for preventing their enlargement. The fact that slopes are not uniform allows the water to accumulate in draws, thus increasing its volume and velocity and multiplying its washing power many times. Unless some means are taken to prevent it, the water soon grinds out a formidable gully.

It is a somewhat common practice to scatter straw in these draws in the fall or to build straw dams across them at frequent intervals. These serve to check the velocity of the water and catch the sediment, but frequently the run-off is so great that the straw is carried down the draw and lodges at the base.

Control of Blowing Soils.—Some soils blow very easily and are damaged by light winds. Ordinarily, however, the soil has a fair power of resistance, and it is only from heavy winds that serious damage may be expected. The velocity of the wind is not the only factor which affects the problem. Its direction and constancy, as well as the moisture content of the air and soil are also of importance. Sandy soils are especially liable to damage by blowing, not only because of their low natural cohesion, but because they are usually well drained. The danger of blowing must always be borne in mind in reckoning the value of sandy lands.

A clay soil is less subject to blowing, not so much because clay particles hang together better than those of sand, though this is of some importance, as because the water-holding power of clay is better, and it is therefore more likely to be able to keep itself moist. It is only a dry soil, or one which can be dried by the wind, that will blow seriously. The exposure of a soil is even more important than its cohesion. If the wind is unable to get at the soil there can be no blowing, no matter how dry or loose the soil or how strong the wind. In nature the degree of exposure depends almost entirely upon vegetation. If a soil is well covered, the lower layers of moving air are entangled in the plants and retarded, and the air next the soil has only a very low velocity. The wind does not reach the soil at all. For this reason, and because of the actual holding of the soil by plant roots, a cover of vegetation is a nearly perfect protection against blowing.

It is obvious that both of the soil factors affecting blowing, namely, cohesion and exposure, are mainly controlled by the water supply. A moist soil is always coherent, and a dry one is only seldom so when loose. Similarly the covering of vegetation (native or artificially planted) which a soil will bear, and hence the degree of protection with which it can provide itself, sustains a direct and closely corresponding relation to the water supply. It is to be expected, therefore, that soil blowing will be an especially serious problem in regions of low rainfall. In the arid region, soil blowing is the rule, while in the humid regions it occurs only in exceptional cases, mainly on sandy soils of very low cohesion and situated in windy regions.

Damage by soil blowing may be and usually is twofold: Directly, to the soil, and indirectly, to the plant or crop covering. The injury to the soil itself is usually through removal, and there are many cases in which the blowing away of the fertile surface layers exposes subsoils insufficiently weathered and filled with humus to be ready for crops. More generally important, however, are the injuries to the crop itself by blowing out or burial, or the direct cutting effect of flying sand grains. The danger is especially great to new seedings or plantings, since a great proportion of the ground is bare and unprotected. It is no uncommon occurrence for farmers in the arid and semiarid sections to lose an entire crop through the blowing out of the seed or the uprooting, burial, or cutting off of the young plants. After the plants are larger they become not only better able to survive burial or exposure of roots, but also more efficient in covering and holding the soil and preventing its blowing.

It is apparent from the facts just stated that the means by which the damage may be prevented or decreased must be, in principle, two: (1) Increasing the cohesion of the soil, and (2) decreasing its exposure to the wind. The cohesion may be increased practically (1) by increasing the water content of the soil, (2) by increasing the amount of humus which it contains, and (3) by modifying its texture, as, for instance, by adding clay or by leaving it in small clods instead of in a finely pulverized condition. The exposure may be decreased (1) by providing a cover of growing vegetation, (2) by leaving the stubble of the last crop still standing on the land, (3) by providing an artificial cover of straw, brush lines, etc., and (4) by planting windbreaks to protect the fields.

In addition to the above methods, the roughening of the surface by proper cultivation really protects the finer soil particles from blowing, as they soon become located in the depressions, where the exposure to the winds is much less.

The degree of usefulness of these various general methods of control in any particular case depends upon local conditions of soil character, climate, the lay of the land, etc. All of them are in use under various circumstances and in varied combinations. Indeed, most of the practical expedients employed to prevent blowing act in two or three of these ways, frequently leading to both increase of cohesion and decrease of exposure.—(Bu. of Soils, Bs. 22, 25, 39, 59, 68, 79; Ariz. E. S. B. 28; Univ. Ill. Bs. 119, 123; Nevada Univ. B. 39; Miss. E. S. B. 66; F. B. 421.)

Authorities Consulted.—Univ. Ill. B. 119; Bu. of Soils B. 68; F. B. 421; Bu. of Soils B. 59; Bu. of Soils B. 69; Bu. of Soils B. 76; Manitoba Ag. Col. B. 7; Bu. of Soils B. 55; Bu. of Soils Bs. 32, 51, 52; R. I. E. S. Rept. 1905; Mich. Ag. Col. B. 219; F. B. 266; Cornell Univ. B. 120; Bu. of Soils Bs. 50, 38; Univ. Neb. B. 114; Bu. of Soils Bs. 9, 1, 2, 3; Mass. Ag. Col. B. 89; Kans. Ag. Col. B. 68; N. Dak. E. S. B. 48; N. Mex. Ag. Col. Bs. 31, 38, 48, 54, 46; Purdue Univ. B. 46; N. Dak. E. S. B. 35; Univ. Minn. E. S. B. 53; N. Dak. E. S. B. 32; Univ. Minn. B. 89; N. H. E. S. B. 138; Del. Col. B. 65; Miss. E. S. B. 132; Del. Col. B. 66; Kans. Ag. Col. B. 117; Bu. of Soils Bs. 161, 17, 16, 15; Univ. Wis. B. 204; R. I. E. S. B. 68; Tex. E. S. B. 129; F. B. 88; Bu. of Soils B. 35; Univ. Wyo. B. 41; S. Dak. E. S. B. 54; Univ. Calif. Bu. of Soils B. 31; Y. B. 1911; Of. Ex. Sta. B. 106; Cornell Univ. Dept. Soils B. 4; Bu. of Soils Bs. 28, 7; Tex. E. S. B. 139; Y. B. 1910; Y. B. 1897; Y. B. 1899; Y. B. 1905; Cornell Univ. R. C. Soil Series No. 1; Cornell Univ. R. C. Series 5; Bu. of Soils B. 15; F. B. 87; F. B. 245; F. B. 257; F. B. 406; Purdue Univ. B. 95; Purdue Univ. B. 57; Clemson Col. B. 32; Univ. Wis. B. 139; Univ. Wis. B. 82; Y. B. 1909; Colo. Ag. Col. B. 65; Cornell Univ. B. 174; Univ. Mo. B. 38; An. Rept. R. I. E. S. 1905; Bu. of Soils B. 22; Univ. Ill. B. 82; Bu. of Soils B. 78; Univ. Minn. B. 30; Y. B. 1906; Univ. Ill. B. 124; Cornell R. C. Soils Series No. 5; Univ. Minn. B. 41; Tex. E. S. B. 126; Bu. Plt. Ind. B. 45; Iowa Col. B. 95; Mich. Ag. Col. B. 7; Mich. Ag. Col. B. 4; Bu. of Soils Bs. 10, 12; Bu. Plt. Ind. B. 201; Of. Ex. Sta. F. I. Lec. No. 3; Fla. E. S. B. 93; Univ. Ill. B. 110; Ore. E. S. B. 90; Bu. Chem. B. 30; Fla. E. S. B. 83; An. Rept. Del. Ex. Sta. 1899; Univ. Wis. B. 205; F. B. 465; F. B. 366; F. B. 78; Ont. Ag. Col. B. 178; Mich. Ag. Col. B. 181; Bu. of Soils Bs. 25, 30, 32, 33, 35, 40, 38, 39, 27, 24, 48, 45, 46, 47, 37, 36, 31, 28, 23, 22, 49, 41, 44, 34, 29; Purdue Univ. B. 33; Univ. Tenn. B. 4; Hawaii E. S. B. 29; F. B. 83; O. E. S. B. 59; Bu. of Soils Cir. 5; Tex. E. S. B. 61; Bu. of Soils B. 56; Bu. of Soils B. 80; Bu. of Soils Bs. 54, 82; Bu. Plt. Ind. B. 173; Bu. of Soils Bs. 70, 53; Univ. Ill. B. 145; Bu. of Soils Bs. 83, 33; R. I. E. S. B. 106; Tex. E. S. B. 129; Tex. E. S. B. 126; Tex. E. S. B. 136; Bu. of Soils B. 72; Colo. Ag. Col. B. 160; Ariz. Univ. B. 235; Univ. Ariz. B. 6; Univ. Ariz. B. 28; Univ. Ariz. 10; Colo. Ag. Col.

B. 72; Bu. of Soils Cir. 7; Fla. E. S. B. 43; Fla. E. S. B. 87; Bu. of Soils Cir. 21; Bu. of Soils Cir. 19; Univ. Idaho B. 9; Univ. Idaho B. 28; Univ. Idaho B. 49; Univ. Ill. B. 150; Univ. Ill. B. 108; Univ. Ill. B. 99; Univ. Ill. B. 123; Iowa Col. B. 82; Iowa Col. B. 94; Ky. Ag. Col. B. 126; Univ. Minn. B. 65; Miss. E. S. B. 132; Miss. E. S. B. 58; Miss. E. S. B. 66; Univ. Mo. Bs. 3, 83, 92, 86, 84 88, 93; Bu. of Soils Cir. 3; Cornell Univ. B. 119; Nev. E. S. B. 39; Bu. of Soils Cir. 20; N. Dak. E. S. B. 24; O. E. S. B. 150; R. I. E. S. B. 121; R. I. E. S. B. 139; Univ. Tenn. B. 3; Univ. Tenn. B. 78; Tex. E. S. B. 43; Tex. E. S. B. 100; Tex. E. S. B. 125; Tex. E. S. B. 99; Utah Ag. Col. B. 52; Wash. E. S. B. 85; Wash. E. S. B. 34; Rept. No. 7, Wyo. E. S.; Univ. of Cal. Cir. 18 Bu. of Soils; R. I. E. S. B. 131; R. I. E. S. B. 120; R. I. Ag. Sta. B. 109; R. I. Ag. Sta. B. 131; Rept. Sec. of Nova Scotia, 1909; Bu. of Soils B. 25; Bu. of Soils B. 22.

FERTILIZATION AND FERTILIZERS.

THE GREAT AGRICULTURAL PROBLEM.

Preserving Productivity.—The foundation of the material wealth of this nation and its position among the nations of the world is the productive capacity of its soils, and, under favorable climatic conditions, there are three principal methods of controlling this productive capacity. These are (1) cultivation, including drainage and irrigation; (2) rotation of crops, and (3) fertilization. Of these, cultivation and rotation are in the hands of the farmer himself. Fertilizing materials, however, have, to a very large extent, to be gathered for him from different parts of the world and manipulated to some extent before they are ready to be applied to the lands. It is generally believed that simple fertilizers, such as muriate of potash, nitrate of soda, or plain superphosphates, when used alone are neither as safe nor as efficient as when used in combination, and as they can usually be mixed more thoroughly by machinery and more cheaply in large quantities, the practice has grown of buying them ready mixed from dealers or manufacturers.

The character of the materials which can profitably be used in these mixtures and the proportion in which the valuable constituents should be contained for the best results for different soils and crops have been a perplexing problem for the manufacturer as well as for the farmer, and have been the subject of much investigation by experiment stations for the past half century.

As a result of the investigations of the experiment stations, we have a fair number of fertilizer materials which can be obtained at prices justifying their application to soils to which they give a moderate increase in crop production. On account, ~~however~~, of their uncertain action, due largely to seasonal differences and changing soil conditions, and of lack of knowledge as to just how they act on the soil or on the plant, we still have little exact knowledge of the kind of material adapted to different soils or crops or the proportions in which the several ingredients should be combined.

Most of the States have efficient systems of fertilizer inspection by which the farmer may determine whether he is paying more for a commercial fertilizer than it would cost him if he purchased simple fertilizer materials and mixed them himself.

Beneficial Effects.—The reason for the beneficial effect of fertilizers has long been held to be due to the supplying of mineral plant food to the soil in a more soluble or available form than is found in soils of low productive capacity. There are three great facts which have never been satisfactorily explained under this hypothesis: (*a*) Stable manure as a rule has a much higher fertilizer value than would be indicated by the amount of mineral plant food elements it contains. (*b*) Plants contain usually as much, or more, of silica, iron, aluminum, magnesium, and sodium as of nitrogen, potash, phosphoric acid, or lime, and the former group are as necessary to plant life and are quite as insoluble in their soil compounds as the latter; they are rarely used successfully as fertilizers, and they are not considered commercially as being in the class of plant foods. (*c*) Certain nonplant food substances, such as copper sulphate, ferrous sulphate, common salt, and some three or four hundred substances which have been tried from time to time do give occasionally very beneficial results. However, it is not always possible to explain any fact by hypothesis, however broad we make it, and as we know that nitrogen, potash, and phosphoric acid are essential elements of plants, and as we often get bigger yields after applying substances containing them to the soil, we have come to look upon the question as proved that they act solely or principally through feeding the plant.

Another fact which we have known for a long time and which we have not been able satisfactorily to explain is that dwarfed plants or plants on infertile soils often contain a larger percentage of ash than better plants grown on more productive soils. This would indicate that on such poor soils they are able to take up more potash, phosphoric acid, and lime than they are able to elaborate into good plant tissue. The most advanced scientific work now shows that fertilizers have another and an important function in keeping the soil sweet and sanitary for the plants.

The natural supply of mineral plant food comes directly from the solution of the mineral particles of the soil. The solubility of these minerals gives a very dilute solution, but adequate in amount and rapidity of solution for the need of field crops. Furthermore, the soil has a great absorbant power, and soluble fertilizer minerals applied to the soil do not long remain in the free or capillary water in which plants are supposed to feed. That is, when a soluble phosphate salt is added to a soil in the usual amount, or even in much greater amount than is ordinarily applied, it can not again be obtained by simply washing the soil, as it is withdrawn from the solution and firmly held by the surface of the solid grains, and the soil moisture is not sensibly enriched by the application.

It is this variation which makes fertilizer practice so uncertain. It is inexplicable from the plant-food idea.

Organic Constitution.—In the decay of the organic matter through fermentation or otherwise, not one but many intermediate bodies are formed, some of which may be beneficial and others may be more or less deleterious to crops and each having different characteristic properties and reactions with mineral salts. In other words, if we look upon the cultivation of the soil as a method to promote fermentation for the purpose of facilitating certain necessary organic changes and of rendering the soil suitable and sanitary for a subsequent crop, we may expect an influence of climate on fertilizer effects, as we would have different intermediate decomposition products formed in the breaking down of the organic matter under different moisture and temperature conditions.

Different combinations of the different plant-food constituents have different effects upon the crop. For example, the different salts of potassium, the different forms of nitrogen in mineral salts and in organic material, and the different forms of phosphorus have different effects on different soils, with different crops, and in different seasons. It is easy to show that it is the substance rather than the element, for the same plant-food element may be in compounds which are more or less beneficial or in other compounds which produce very unfavorable conditions in the soil, rendering them more toxic for plant growth. Such in a broad way is the present state of knowledge in regard to the principles of fertilizer effects on soil fertility.

The Bureau of Soils has made a thorough comparative investigation of the fertilizer and manurial requirements of several hundred samples of soils from various parts of the United States, under as nearly as possible the same climatic conditions. These investigations show that fertilizers are relatively more effective on light than on heavy soils; also that they give, as would be expected, the greatest relative effect on poor soils rather than on rich soils, when both are put in good physical condition.

For the greater number of soils the most efficient fertilizers of the future will be of organic rather than mineral origin, provided that when such a substance is found it can be obtained in sufficient quantity and a sufficiently low cost and be at the same time less bulky to ship than stable manure.

There is a general feeling, although this does not seem to be borne out in practice, that both nitrate of soda and potash are more efficient in moderately cool climates and phosphates and organic nitrogen in warmer climates. The Bureau of Soils' comparative study under similar climatic conditions indicates that on the soils of the North Central States manure is about three times as efficient as mineral fertilizers.

Effects on Different Soils.—In the soils of the Atlantic and Gulf States manure and green manure are about equally as effective as mineral fertilizers. It must not be forgotten that on certain soils, either under field conditions or in pots, manure appears to be deleterious and on some soils mineral fertilizers likewise appear to be deleterious, although the cases where either of these extreme results occur are very rare.

The beneficial effect of stable manure is due principally to the organic constituents of the manure rather than to the mineral salts which it contains. We know, too, that the same food passing through a man, horse, cow, pig, or poultry gives, with the same mineral consituents, manure of very different properties and values, because of the difference in the character of the organic constituents resulting from the difference in the digestive processes and metabolic processes in the animals through which the food has passed.

In the case of horse manure it is advisable, and for some soils, as well as for some plants, necessary, to give the manure a preliminary fermentation before it is applied to the soil. In other words, on some soils we can safely use fresh manure and even have it contain a great deal of coarse litter, while on other soils we can safely use only well-fermented manure in which even the litter originally present has lost its form and has become well broken down. Straw as such is often deleterious when applied directly to the soil and turned under, but straw mixed with manure and partly fermented in the manure pile is beneficial to most soils, indicating a difference in the way decomposition proceeds, whether this starts directly in the soil or in the manure pile.

There is evidence, therefore, that the fertilizers do something to the soil to put it into better condition for crops. In disappearing the fertilizers have performed some function, have acted on some constituent of the soil perhaps that had heretofore retarded the growth of plants, and, by its removal, oxidation, or other change, have rendered the soil a better medium for the growth of the plant.

The results of fertilizer tests and the experience of farmers seem to indicate that in a majority of cases nitrates increase vegetative growth of plants; phosphates tend rather to check this vegetative growth or to produce relatively more seed, while potash appears to promote starch-forming activities (develop tubers in potatoes) and to improve the quality of fruits (for example, apples). Combinations of these elements often seem to show in their effect the results which would be expected from each alone, that is to say, a mixture of nitrogen and phosphorus may increase the vegetative growth and also increase the amount of grain produced on the wheat plant. By adjusting the proportion of these elements it has doubtless been possible in many cases to modify the crop within the limits as desired. So, in the same way, with potatoes, a moderate supply of nitrogen, either in the form of nitrate of soda or of organic matter, in conjunction with potash, often produces an increased growth of vine necessary for an increased development of tuber.

Another fact which must be borne in mind is that these effects are greatly influenced by weather conditions. It is a common experience that a brand of fertilizer or a single fertilizer constituent which has a decidedly beneficial effect this year may have little or no effect on the same soil and the same crop another year when the weather conditions are markedly different.

Of the organic matters used directly or indirectly as manure, the most effective are those containing a large proportion of nitrogenous bodies. The leguminous plants are the most effective as green manure and the manure from a grain-fed horse is more effective than from a horse fed principally hay or on pasture. The protein bodies are as a rule very complex and break down through oxidation, fermentation, and the action of enzymes or bacteria into bodies many of which are now known to be beneficial or detrimental to plants. The same original substance may break down into beneficial or detrimental substances, according to the agencies acting on it and the conditions under which they act. Fresh pea vines and pea-vine hay may, and usually do, give very different results when applied to any particular soil. Ground wheat seed and germinating wheat seed have very different effects on the soil. So it is evidently not the nitrogen, but the compound, which determines the action on the soil.

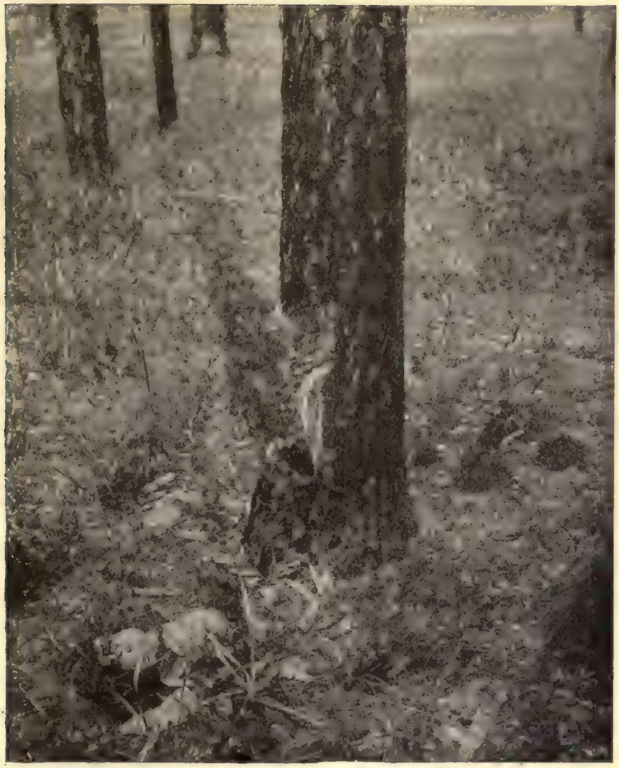
It is generally believed that the beneficial effect of nitrogenous fertilizers is due to nitrification, through bacterial action, with the ultimate formation of nitrates, and this is undoubtedly important, not so much because of the nitrates formed, but because decomposition proceeding in that way is generally more beneficial than if it proceeds in other ways when other less beneficial intermediate products may be formed.

Carriers of Nitrogen.—The substances commonly used as carriers of nitrogen are nitrate of soda, sulphate of ammonia, cotton-seed meal, dried blood, tankage, fish scrap, guano, and castor pomace. Other nitrogenous substances, like horn, hair, feathers, and wool waste, are prohibited by the laws of many States from being incorporated into commercial fertilizers, as they are not considered good substances for fertilizer use, although they are highly nitrogenous.

The substances commonly used as carriers of potassium are kainit, muriate of potash, sulphate of potash, and carbonate of potash. There are other potash salts, as, for example, iodide of potash and chlorate of potash, which are harmful and could not be used in fertilizers even if they could be obtained cheaply enough.

It is the experience of farmers and investigators generally that these different carriers of phosphorus, of nitrogen, and of potash act differently on different soils and in different seasons and with different crops—that is, that raw rock phosphate, ground bones, bone-black, acid phosphate, floats, and slag are different substances which may act differently on different soils with different crops and with different seasons. Likewise that nitrate of soda, sulphate of ammonia, cotton-seed meal, dried blood, fish scrap, and guano are different substances in an agricultural as well as in a commercial sense, and this in addition to their differences in nitrogen content.

Most tobacco growers and many truck and fruit growers recognize a difference in the agricultural value of kainit, muriate, sulphate, and carbonate of potash as influencing the quality if not the yield of their crops. It is true that no definite law has ever been worked out even for a particular field, but this is probably due in large measure to a lack of knowledge of how these substances act and the influences which control their action on the soil.



Side View of "Box" Cut in Base of Tree for Collecting Crude Turpentine, Showing Depth of Wound. Dept. of Agr.

An Earth "Tank" or Reservoir for Irrigating Small Gardens and Fruit Plantations. Dept. of Agr.

It seems entirely probable that in the future we will require to know in buying commercial fertilizers not only the percentage composition of plant-food constituents, but the nature of the substances containing them. This would presuppose that the farmer knew whether nitrate of soda, cotton-seed meal, or dried blood would give the better results on his soil and for the crop he proposes to grow—a fact which it is not difficult to imagine he could determine for himself within limits with the wire-pot method devised and described by the Bureau of Soils.

Lack of Knowledge.—Everyone who has given any thought to the matter realizes the woeful confusion and lack of intelligent control there is in our fertilizer practice. This is due solely to our lack of knowledge of the real functions of fertilizers. We buy what is offered to us on a basis of the percentage of potash, nitrogen, and phosphoric acid, without a knowledge of the character of the ingredients. The manufacturer and dealer offer us the best they can, and their goods are nearly always up to the guaranty so far as plant-food elements are concerned, but neither the manufacturer knows, nor do those who make the purchase know, what carrier the element should be in to suit their particular needs.

The experience of farmers and the results of scientific investigation show that both the material and the proportion of the different materials in a mixed fertilizer may have an important influence on the results for any particular soil, so that it would seem highly important that each brand of fertilizer should have a guarantee as to the kind and amount of each ingredient in which the desirable plant-food ingredient is carried.

That it is the material rather than the elements contained which determines the possible agricultural value of the fertilizer is becoming more and more evident every day. It is not believed by any competent person that nitrate of soda, sulphate of ammonia, and the various organic forms of nitrogen commonly used in fertilizers are equally effective on all soils, crops, and in all seasons. Indeed, there is undoubted evidence that they may differ widely, and yet they are applied more or less indiscriminately and without certain knowledge of what is being used in commercial fertilizers.

Want of System.—There is no rational system of fertilization in general use in this country, and in this respect the United States appears to be far behind some of the European countries. We have indeed a general idea of the form of fertilizer material adapted to some of our soils and crops, and some idea of the relation of soil conditions and climatic conditions to fertilizer action, but these ideas are very seldom based upon any exact data, and practically are not applied by fertilizer manufacturers or farmers. The advice of agricultural chemists and agronomists is almost always that the farmers should test their soils by plat experiments to determine the most efficient forms and combinations of fertilizers. Such experiments are costly and take time, and results vary with different seasons. Such experiment stations as have carried on these fertilizer tests hesitate to draw conclusions with less than an experience of ten years.

It has been asserted that corn is particularly responsive to phosphates, cereal crops to nitrates, grasses and clovers to phosphoric acid and potash, beets and carrots to nitrogen, potatoes and sweet potatoes to potash, and truck crops to nitrogen; and yet with only this meager information, not pretending to be exact or invariable, we find a multitude of brands on the market, many of them being prepared and recommended for special crops. One has but to look up the reports of the state departments of agriculture and the state experiment stations charged with the inspection of fertilizer materials to see the absolute lack of system which prevails in the fertilizer trade. The tendency in this country seems to run to an increase in the number of special brands for special crops, but there is an absolute lack of uniformity even in the elementary composition of these special brands. As a rule the fertilizer formulas are simpler and more uniform in the South than they are in the North; there are also a less number of special brands for special crops.

It is the general belief at the present time that a fertilizer for tobacco should be rich in potash and that for cigar tobacco the potash should be in the form of carbonate, yet we find special brands for tobacco with from 1 to 3 per cent of potash, and so far as the evidence permits one to judge the potash in the majority of brands is not in the form of carbonate. It would seem that it would be a protection to the farmers to prohibit the use of the word tobacco on a brand of fertilizer containing less, say, than 6 per cent of potash in the form of carbonate only.

It is the general belief that potatoes require fertilizers rich in potash and that it is better to have the potash in the form of sulphate, yet brands of special fertilizers for potatoes are offered for sale with only 2 and 3 per cent of potash. It would be a protection to the farmers to prohibit the use of the word potatoes on any special brand for potatoes with less than a minimum of, say, 6 per cent of potash, and this in the form of sulphate only. It is the general belief that sugar beets require a fertilizer rich in potash and that it is best to have this in the form of chloride or muriate, but no particular attention seems to be paid to this in the preparation of special brands and the farmers do not know what materials they are purchasing.

There is a choice also in respect to action on the crop. This will depend somewhat on the character of soil and can only be learned by experience. One fertilizer will appear to be best one year or on some crops and land, and another season, owing to the different weather, wet or drought, or on other land or plants, another kind of fertilizer will give the best results.

It is a fact of common farm experience that nitrogenous manures differ widely in their efficiency. Nitrate of soda, for example, often has a visible effect on grass land within ten days after sowing, dried blood requires a longer time to affect the color or growth of grass, while an application of leather or hair may never show the slightest effect.

A considerable number of manufacturing wastes, rich in nitrogen, but differing greatly in their value as plant foods, are now on the market, and their use is urged upon manufacturers of mixed fertilizers. In general, such of these waste products as are agriculturally of least value are also least expensive, and therefore the temptation to use them in manufactured goods is to some very strong.

It is highly desirable to know in the first place how these nitrogenous wastes compare with each other, and with some standard, such as nitrate of soda, in availability, and various experiments have already accomplished something in this direction. In the next place it is important, either to be able to identify these various "ammoniates" in mixed fertilizers, or else to have some means of distinguishing in such fertilizers between available and inert nitrogen —some measure of its availability. Unfortunately, it has hitherto been difficult or impossible to identify with certainty most of the inferior ammoniates either by inspection or by ordinary chemical tests. The treatment with acid during the process of manufacture, the grinding and the mixture with phosphatic material and potash salts, so alters the structure and appearance that in many cases the microscope fails to identify any thing and chemical tests are not generally applicable.

The most satisfactory, and, indeed, usually the only method by which we can at present determine the needs of a soil is to ask the question of the soil itself by growing a crop upon it with different kinds of fertilizers and noting the result. Such soil tests with fertilizers have in many cases given results of much immediate practical value for the locality in which they were undertaken. Many materials containing the essential elements are practically worthless as sources of plant food because the form is not right. All materials containing organic nitrogen are valuable in proportion to their rapidity of decay or change. Thus organic nitrogen differs in availability not only according to the kind of material which supplies it, but upon the treatment it receives. The phosphoric acid in natural or untreated phosphates is insoluble in water and not readily available to plants; that is, the rate of availability depends largely upon the rapidity with which the substance rots or decays, and the rate of decay again depends upon the character of the substance with which the phosphate is associated. Potash may exist in a number of forms, though chiefly as chlorids, or muriates, in which case the potash is combined with chlorin; and as sulphates in which the potash is combined with sulphuric acid. With potash, however, the form does not exert so great an influence upon availability as is the case with nitrogen and phosphoric acid. All forms are freely soluble in water, and are believed to be nearly if not quite equally available as food. The form of potash has, however, an important influence upon the quality of certain crops, due rather to the constituents with which the potash is associated than to the potash itself. The character or form of the materials used must, therefore, be carefully considered in the use of manure. All manufactured products or brands of fertilizers are made up of a mixture of the various kinds and forms of fertilizing materials just described, and the differences that exist in the brands of different manufacturers are due both to differences in the character and to the variations in proportions of the materials used to form the different brands; that is, while all manufacturers must go to the sources of supply they may select either good or poor products and may vary the proportions of the different materials used. The difference between a good brand of fertilizer and a poor one lies not so much in differences that may exist in the total amount of plant food contained in it as in the quality of the materials of which it is made.

Use of Fertilizer.—There is no question as to the desirability of the use of commercial fertilizers on most farms, though the methods now generally practiced are such as to indicate the very great need of a better understanding of what the functions of a fertilizer are, of the terms used to express their composition and value, of the kind that shall be used, and the time and method of application for the different crops under the varying conditions that exist.

The practical point, and the one of prime importance to the farmer, is to know how to estimate the relative value or usefulness of these different products, what is the rate of availability as compared with nitrate, and thus the relative advantage of purchasing the one or the other at the ruling market prices. Relative values, however, can not be assigned as yet, though careful studies of the problem have been made, chiefly by what are known as "vegetation tests"—that is, tests which show the actual amounts of nitrogen that plants can obtain from nitrogenous products of different kinds, when they are grown under known and controlled conditions. The results so far obtained, while only serving as a guide, indicate that when nitrate is rated at 100 per cent, blood and cotton-seed meal are about 70 per cent, dried and ground fish and hoof meal 65 per cent, bone and tankage 60 per cent, and leather and wool waste range from as low as 2 per cent to as high as 30 per cent. These figures furnish a fair basis for comparing the different materials, when used for the same purpose or under the same conditions. If, for example, the increased yield of oats due to the application of nitrate of soda is 1,000 pounds, the yield from blood and cotton-seed meal would be 700 pounds, the yield from dried ground fish and hoof meal would be 650 pounds, from bone and tankage 600 pounds, and from leather, ground horn, and wool waste from 20 to 300 pounds.

These figures alone are, however, not a sufficient guide as to the kinds to buy under all conditions, since the usefulness of the different forms are again dependent upon such other conditions as the kind of crop, the season, and the object of the application.

In the making up of fertilizers, all of these considerations should be carefully balanced, and it is the practice on the part of many manufacturers to use a part of each of the three forms, so that a continuous feeding of the plant may be insured. Therefore, while the fact remains that fertilizers containing only the one form may not be the poorest, the chances are that those which contain all forms are likely to give more satisfactory results.

It [potash] is, however, a very necessary constituent of fertilizers, being absolutely essential for those intended for light, sandy soils and for peaty meadow lands, as well as for certain potash-consuming crops, as potatoes, tobacco and roots, since these soils are very deficient in this element, and the plants mentioned require it in larger proportions than do others.

Potash exists in various forms, but it differs from the other elements in that its chemical form or combination seems to exert but relatively little influence upon the availability of the constituent. For example, it may be in a form of muriate or chlorid, of a sulphate or of a carbonate, and while there is a difference in the diffusibility of these different compounds—that is, a difference in the rate at which they will distribute in the soil before becoming fixed—there seems to be very little difference in the rate of the absorption of the potash by the plant. Nevertheless, the form of potash must be observed, because of the possible influence that the substances with which it combines may exert in reducing the marketable quality of the crop to which it is applied. This influence has been very distinctly observed, particularly in the growing of tobacco, sugar beets, and potatoes, and it has been shown that the potash in the form of a chlorid (or muriate) does exert a very deleterious effect, especially on tobacco.

In the purchase of mixtures, consumers should demand that they be accompanied by a guarantee, because they are unable to determine the kind and proportion of the different materials entering into the mixture, either by its appearance, weight or smell. In mixing, too, an opportunity is afforded for disguising poor forms of the constituents, particularly nitrogen. That is, in a mixture of nitrogenous materials, potash salts, and superphosphates, it would be a difficult matter to determine, by mere physical inspection, the proportion of the nitrogen which had been supplied in the form of horn meal and of blood, and the statement of the manufacturer on this point would be valuable in proportion to his reliability.

An analysis may show simply the total amount of the constituents. This is not a sufficient guide as to the value of the mixture, for while it is not possible to indicate absolutely by analysis whether the organic nitrogen, for example, is derived from blood (which is one of the best forms) or from horn meal (one of the poorer forms) it is possible to show whether the nitrogen is derived from nitrate or from ammonia, whether the phosphoric acid is derived from a superphosphate or a phosphate, and whether the potash present is in the form of a sulphate or of a muriate. A high-grade or a low-grade fertilizer, for example, may be distinctly indicated by the analysis, since it is of a high grade if the three forms of nitrogen are present, if the total phosphoric acid is chiefly soluble in water, and if the potash has been derived from a sulphate or from a muriate. It is obvious, that the value of a fertilizer to the farmer depends not so much upon what is paid for it as upon the character of the material used to make it.

The chemical analysis does not show absolutely the sources of the materials, and thus it is difficult to place a true commercial value upon a mixture. This is especially true of organic nitrogen, since because it is impossible to separate the amounts that may be derived from different materials, a uniform value is placed upon the total nitrogen found, whether it is derived from the best forms, as dried blood and dried meat, or whether derived from horn meal, ground leather, or other low-grade forms of nitrogenous materials. This encourages the use of low-grade products by unscrupulous manufacturers, to the real detriment of the trade as a whole.

Any system of comparison of brands must leave a great deal to the judgment of the purchaser. He must interpret for himself whether he would rather that his phosphoric acid were derived from one source or another.

The primary object in the use of a commercial fertilizer is to receive a profit from the increase in the yield of crops from the land to which it is applied; and this may be derived either from the immediate crop or from the larger yield of a number of crops. That the greatest immediate or prospective profit may be gained, a wide knowledge of conditions which have either a direct or indirect bearing upon the result is essential.

In fact, the controlling conditions surrounding the matter are so numerous and so various that it is impossible, with our present knowledge, to lay down positive rules for our guidance. At best, only suggestions can be offered.

Modified by Soil.—It must be remembered that only general rules apply in the use of fertilizers upon soils of different classes, and that they are modified by both the chemical composition and the mechanical condition of the soil. The best use of a fertilizer—that is, the greatest proportionate return of plant food in the crop, all things considered—is obtained from its application upon soils that possess condition, or that are well cultivated or managed. Full returns cannot be expected when they are applied upon soils that are too wet or too dry, too porous or too compact,—or too coarse or too fine. It is important that even the best soils should be properly prepared, and it is infinitely more important that those which possess poor mechanical conditions should be improved in this respect before large expenditures are made for fertilizers.

The most expensive and irrational system, and one more commonly practiced than any other in general farming, may be termed the hit or miss system. If a hit is made, there is a profit, if a miss the loss is trifling. In this system no special thought is given to the character of the crop or its needs. If the farmer can afford it, he purchases a fertilizer, without regard to its composition, and applies it in very small amounts. If it happens to contain that element which is particularly needed for the plant to which it is applied, a profit is secured. In too many cases, however, the constituents added are already in abundance in the soil, or so little of the fertilizer is used as to preclude any profit.

The lacking element can not be fully determined, except by direct experiments by the farmer himself. That is, no general principle can be depended on as an absolute guide. He should learn whether his soil is deficient in any of the elements, and, if so, which one should be applied to the different crops in his rotation. A careful study along this line, too, will show whether it is fertilization that is required to meet seeming deficiencies, for it frequently happens that the needs of the soil are not so much for added plant food as for better management of the soil in other respects.

The results of experiments which have been conducted with great care in a number of states show that where extensive methods are practiced certain elements need not be added in the fertilizers; that is, that the soil contains such an abundance of them that the plant is able to obtain a full supply, at least for a long time. For example, it has been shown that on the chief sugar-producing soils of Louisiana and Mississippi, and the cotton soils of Georgia and Texas, the addition of potash has been of less importance in the past than the other elements, and it frequently does not need to be included in the fertilizer, while phosphoric acid is always needed.

The results of field experiments on this plan in New Jersey, on reasonably good, loamy soils, indicate that phosphoric acid and potash are of much more importance in fertilizers for corn than nitrogen, whereas upon sandy soils nitrogen and potash are of relatively more importance than phosphoric acid; that is, even where extensive practice is used there are conditions where one or more of the elements are not required in order to secure maximum crops, which eliminates the necessity for an immediate outlay for those constituents that are not lacking. Where experiments of this sort have not been carried out and the specific needs determined, it becomes necessary to assume that all of the constituents are required, and to apply the amounts and proportions of those which the general considerations of the soil, season, climate and crop would seem to demand.

The methods of fertilization here suggested, though in many instances apparently positive, are not to be interpreted as absolute rules, but rather used as guides, based upon the best information that it has been possible to obtain, both as a result of scientific inquiry and of practical experience.

The main point in this whole matter of fertilization is to understand that a fertilizer is a fertilizer because of the kind and form of plant food contained in it; and that its best action, other things being equal, is accomplished when the soil possesses good physical qualities, when the management is also good, and when systematic methods are planned and adopted. Hit or miss fertilization, even for these crops, may pay, and doubtless on the average does pay as well as some other things that farmers do, but does not pay as well as it might if better methods were used.

There is a vast difference in the natural fertility of soils. Some do not produce well from the start unless special attention is given to making them productive; others produce large crops for a short time and then rapidly diminish in fertility; while others known as strong soils remain productive for many years without attention to their fertility. But even the strongest soils will wear out in time unless they are intelligently managed. Plants take from the soil certain elements that are necessary for their growth, and these elements must be returned to the soil in some way. Rotation of crops, the growth of legumes, and the use of some fertilizing material are the three methods in use. Rotation and the growing of legumes help but will not do by themselves. Neither will the use of a fertilizer accomplish the desired results without intelligent management in other respects.

Weather Conditions.—It should always be borne in mind that the success of a crop depends on four other conditions besides that of the fertilizer used to feed it. All farm crops require certain average amounts of heat, light, air, and water in order to develop an average growth, and just the right amount of each for the largest possible yield.

Thus weather conditions may favor or hinder a crop to such an extent that the fertilizer has apparently no effect, and these facts have led more than one to the conclusion that fertilizers were useless.

Fertilizers can not make good a lack of sunshine or rain, but they can help the sunshine and rain to do their best; therefore when the weather is favorable they increase the profits and when it is unfavorable they lessen the losses.

The condition of the soil in its relation to air and water is of the greatest importance in the profitable use of commercial fertilizers. When a soil is too wet, it allows too little air to reach the roots of plants, simply because the water crowds it out. In average seasons some soils are too wet and others are too dry for the following reasons: A crop of 3 tons of hay or one of 15 tons of silage corn per acre would result in the removal from the soil of about 800 tons of water. To supply this water, there would need to be between 7 and 8 inches of rainfall during the growing season of each crop. If this rain were uniformly distributed, it would be fully enough for grass and a little too much for corn. As it is not, both crops need the soil in such condition that it will hold enough water at all times for their needs, while allowing the surplus to drain away.

On soils of average texture the requisite moisture conditions can be maintained by tillage, and if needed, by drainage on low levels; but with extreme types, as heavy clay loams or light sandy loams, there is needed more thorough treatment by increasing the amount of vegetable matter, since there is no more effective way of making over a soil in its relation to water and air than this.

In using commercial fertilizers as a source of the food elements needed by crops, it should be remembered that there is little positive evidence that they can make over the soil in its relation to water, hence they always do their best work and are most profitable on soils which are in good average condition, neither too heavy and wet nor too light and dry. Furthermore, the continuous growth of annual crops, whether hoed or broadcast, adds no vegetable matter to the soil, except in the roots and stubble, and it is common to find that the first crop of corn, on sod land, with commercial fertilizers, is superior to that of the second year, undoubtedly because the vegetable matter of the old turf helped maintain a satisfactory moisture condition in the first year and was largely destroyed before the second year.

The most economical use of commercial fertilizers is only reached when they are applied in rotation in which the soil is maintained in good moisture condition by the use of barnyard manure or the vegetable matter from crops grown for the purpose. Although the food elements in a commercial fertilizer form but one of the several conditions needed for the best development of the crop, it is important that these elements should be suited to the demands of the crop at every stage of its growth, else the product will not be as large as the other conditions would permit. It is the most common practice to use this class of fertilizers with the annual crops, and there are good reasons for such practice, as shown by fertilizer experiments.

Annual crops, whether oats, corn, potatoes, or vegetables, require that their food elements shall be ready to hand as their growth makes new demands. The commercial fertilizer, then, should be able to furnish available food elements throughout the growing season, and in the proper proportion required by the crop. A study of the chemistry of plant growth shows very clearly that there must be present a continuous supply of available nitrogen, which requires that some shall be in the inorganic and some in organic form.

The more quickly the crop is to be grown in the spring the more inorganic nitrogen will be needed, since it is sooner ready for the plants than organic forms. Soluble phosphoric acid produces results more quickly and thoroughly than the other forms, and a well-made fertilizer should have at least half of its available phosphoric acid in the soluble form. All crops remove from the soil much more potash than phosphoric acid, and although the soil may furnish some of it, without the positive evidence of field experiments to that effect, a fertilizer should have at least as much potash as it has soluble phosphoric acid.

Commercial fertilizers may be advantageously used in topdressing grass and for such a purpose it should have a high percentage of nitrogen, of which nearly all should be inorganic. The phosphoric acid should be nearly all soluble in order to be of marked benefit, and the fertilizer should be applied in early spring while the soil is thoroughly moist.

Finally, in the purchase of fertilizers it should be borne in mind that it costs just as much to mix, bag, freight, and handle a ton of low-grade fertilizer as one of high grade. By purchasing a half ton of the highest grade goods one buys more and better nitrogen, as much potash, and enough phosphoric acid to balance them, for less money than he would pay for a ton of low-grade goods, because he saves half the cost of the above different items.

An economical use of manurial substances from any source is only possible after the local condition of the soil under consideration as well as the special wants of the crops to be raised, are each duly considered. It becomes the business of every progressive farmer to acquire such information as is called for to select intelligently from the various manurial resources at his disposal, those materials which will meet best his wants for a complete fertilizer.

The mechanical condition of any fertilizing material, simple or compound, deserves the most serious consideration of farmers, when articles of a similar chemical character are offered for their choice. The degree of pulverization controls almost without exception, under similar conditions, the rate of solubility, and the more or less rapid diffusion of the different articles of plant-food throughout the soil.

The state of moisture exerts a no less important influence on the pecuniary value in case of one and the same kind of substance. Two samples of fish fertilizers, although equally pure, may differ from 50 to 100 per cent in commercial value, on account of mere difference in moisture.

It is of the first importance when buying fertilizers for home consumption to consider their cost with reference to what they promise to furnish. The high priced fertilizers may prove in many instances cheaper than the lower priced one—when judged from that standpoint.

The agricultural value of a fertilizer is measured by the benefit received from its use, and depends upon its fertilizing effect, or crop-producing power. As a broad, general rule, it is true that Peruvian guano, superphosphates, fish-crabs, dried blood, potash salts, plaster, etc., have a high agricultural value which is related to their trade value, and to a degree determines the latter value. But the rule has many exceptions, and in particular instances the trade-value can not always be expected to fix or even indicate the agricultural value. Fertilizing effect depends largely upon soil, crop and weather, and as these vary from place to place, and from year to year, it can not be foretold or estimated except by the result of past experience, and then only in a general and probable manner.

The agricultural value and the commercial value of fertilizing materials are not synonymous terms. The agricultural value of a fertilizer is determined by the increase and quality produced by it in the crop. The commercial value of a fertilizer is determined by the cost of the materials which enter into its composition. A fertilizing material of high commercial value may have a low agricultural value on a particular soil or crop. On another soil or crop the same material may have a high agricultural value.

Plant food is not the only condition which controls the growth of the crop and the corresponding yield. In fact it may, at times, be of a relatively small importance. The size of the crop depends on the condition least favorable to its growth. The controlling condition may be excess or deficiency of water, too low or too high a temperature, too much or too little light, the depth of the soil, the physical character or condition of the soil, the quantity available of any given plant food, acidity of the soil, insect pests, or plant diseases, kind of seed, etc.

The controlling condition may not be constant. At one period during the growth of the crop, excess of water may control. At another time deficiency of, say, phosphoric acid, may control. Later on, drought may set in, and deficiency of water become the controlling condition.

The conditions of plant life are not independent, but affect one another. An excess of water interferes with the elaboration of plant food. The physical condition or character of the soil affects the amount of water it retains. A liberal supply of plant food may economize water, and so on. The practical farmer must study the limiting conditions, and endeavor to raise the limit to a higher one. A knowledge of the limiting condition, thus, is of prime importance.

A study of the relation of Texas soils to water is, we believe, of great importance. Moisture and other climatic conditions, are the great controlling conditions. Methods of removing surplus waters, and of storing and conserving water in the soil, should be learned and practiced by the farmer.

(Authorities.—Mass. E. S. B. 51; Conn. E. S. Rept. 1900, 1902, 1903, 1905, 1907; Bu. of Soils B. 55; Univ. Wis. B. 180; N. H. Col. B. 83; Tex. E. S. Bs. 85, 112, 138; F. Bs. 44, 56, 65, 245, 259, 398; Bu. Plt. Ind. Bs. 58, 441, 692; Mass. Ag. Col. B. 45; Ala. Dept. Ag. Bs. 2, 9; Univ. Vt. B. 154; Univ. Ill. B. 129; Cornell Univ. B. 201; Cornell Univ. Cir. 7; Univ. Calif. Bs. 157, 173, 179; O. E. S. B. 159; N. H. E. S. B. 5; W. Va. E. S. Bs. 5, 51, 80, 114; La. E. S. B. 31; Fla. E. S. B. 20; Purdue Univ. Bs. 10, 92; Wash. Univ. Bs. 19, 37; Ky. Univ. B. 140; N. J. E. S. B. 157; Univ. Tenn. B. 86; Univ. Tenn. Rept. 1899; Mass. Ag. Col. B. 14; Mass. E. S. Rept. 1907; F. B. 329; Ala. Ag. Dept. B. 10; Cornell R. Course No. 9; O. E. S. B. 124; Purdue Univ. B. 106; Univ. Wash. B. 98; Conn. E. S. Rept. 1906, 1908; W. Va. Univ. B. 97; O. E. S. B. 184; Clemson Col. Bs. 4, 19; Univ. Tenn. B. 92; Univ. Ill. B. 109; Tex. E. S. B. 107; Univ. Calif. Bs. 187, 194; O. E. S. Bs. 54, 83, 182; Clemson Col. Bs. 12, 15; Ga. Ag. Col. B. 72; N. H. E. S. B. 123; Minn. E. S. B. 47.)

FARM MANURES.

Value of Farm Manures.—The fertility of the soil would remain practically unchanged if all the ingredients removed in the various farm products were restored to the land. This is to a large extent accomplished by feeding the crops grown on the farm to animals, carefully saving the manure and returning it to the soil, and where it is practicable to pursue a system of stock feeding in which those products of the farm which are comparatively poor in fertilizing constituents are exchanged in the market for feeding stuffs of high fertilizing value, the loss of soil fertility may be reduced to a minimum, or there may be an actual gain of fertility.

The conservation of fertility in the soil may be accomplished by either of two methods: (1) By feeding crops and purchased concentrated feeds to live stock and applying the stable manure to the land; (2) by the application of commercial fertilizers and culture of legumes and other crops to maintain the humus content of the soil. By the former method live stock is kept in sufficient numbers to consume most of the crops grown on the farm, together with a certain amount of concentrated feeding stuffs, which are purchased.

In order to overcome the exhausting effect of crop production on soil fertility, systems of fertilization have been practiced by farmers since the dawn of agriculture. The simplest, oldest and, as a general rule, the best method at hand is to feed the crops to farm animals and apply the manure produced by them on the land. In live stock farming more stock is kept than is required to supply the needs of the farm household, and the method of farming is changed from grain-raising or general farming to stock-raising or dairying. This change has to a large extent taken place in all eastern and central states, and farmers in the grain-raising sections are gradually abandoning the old ruinous system of continuous cropping.

In live stock farming the crops raised on the farm are grown primarily for the purpose of feeding one or more classes of live stock, and but little is sold except animal products; on the other hand, concentrated feeding stuffs are purchased for feeding the farm animals, which add to the amount of fertility returned to the land in the manure. Since the animal products, sold do not, as a general rule, contain large quantities of fertilizer ingredients it is possible even to increase the fertility of the land by this system of farming.

Farming without the use of manures is a waste of energy and results in the exhaustion of soils. The neglect in preserving and increasing the quantity of farm manures has been a great drain on the natural resources of the American farm, especially in the southern portion of the United States. The lack of intelligent care of the waste products and the convenient form of commercial fertilizers have jointly been responsible for the almost general neglect of farm manures.

Properly handled, stable manure is by all means the best remedy for poverty of the soil. Very few farmers handle manure so as to get even as much as half the possible value from it. There is probably no greater waste in the world than in connection with the handling of manure by the American farmer. Five-eighths of the plant food in manure is found in the liquid part of it. This is usually all lost. Not only is this the case, but the solids are piled beside the barn, frequently under the eaves, where rains wash away much of their value. Fermentation in these manure piles also sets free much of the nitrogen to escape into the air.

The sole object of agriculture is the production of such plants as contribute to the satisfaction of the wants of mankind. The soil constitutes a magazine of the materials of crop production. The whole range of vegetable production embraces fourteen elementary substances; but not all of these fourteen are necessary to every species, nor to the same species under all circumstances. All of these substances are to be found in all soils in various forms and degrees.

It is the business of the farmer, by the various processes of cultivation, to combine these several elements in the production of such crops as he proposes to make. Every plant is its own chemist, with the soil for its laboratory, and may be implicitly trusted to take care of itself, if the materials in a condition suitable to serve as food are placed within the reach of its roots. The amount of the several elements that are withdrawn from the soil by the plant are exactly represented by the crop, just as a piece of cloth represents the cotton, or other material out of which it is made. The first inquiry which addresses itself to the farmer who proposes to increase the product of his land by the use of fertilizers is, what is the most economical means of effecting this object.

The great competition in all industrial pursuits,—and in farming not less than in others—has narrowed the margin for profits to such an extent as to render success dependent upon judicious, and especially upon the economical employment of means. Thrift in farming will be found largely dependent upon the use of home-made fertilizers; chief among which is barnyard manure. This can be most easily and economically applied after having been composted with such other waste material as may be available.

The efficacy of barnyard manure depends upon precisely the same elements as are offered to the farmer in the various chemical fertilizers—the chief constitutents in all being phosphoric acid, nitrogen and potash. These three elements are required by different crops and different soils in very different proportions. Whilst they are all present in barnyard manure, yet they exist in proportions very different from that in which they are required by the several crops which are most commonly produced with us.

The fertilizing value of barnyard manure, as of any material, is, however, not determined exclusively by the total amounts of nitrogen, phosphoric acid, and potash it contains, but depends to a very large extent upon the ease with which these constituents are utilized by the plant, that is, upon their availability.

Barnyard manure is the most important manurial resource of the farm and should be carefully saved and used. It represents fertility which is drawn from the soil and must be returned to it if productiveness is to be maintained. It not only enriches the soil with the nitrogen, phosphoric acid, and potash, but it also renders the stored-up materials of the soil more available, improves the mechanical condition of the soil, makes it warmer, and enables it to retain more moisture.

On the basis of prices charged for commercial fertilizers it is estimated that the average value of the manure annually produced by each horse or mule is $27, by each head of cattle $19, by each hog $12, and by each sheep $2. Probably less than half these values are actually realized in practice.

The urine is by far the most valuable part of the excreta of animals. It is especially rich in readily available nitrogen, which rapidly escapes into the air if special precautions are not taken to prevent its loss. It is also rich in potash, but deficient in phosphoric acid. It should as a rule, be used in connection with the solid dung, the one thus supplying the deficiencies of the other and making a more evenly balanced manure.

Barnyard manure is a very variable substance, its composition and value depending mainly upon (1) age and kind of animal, (2) quantity and quality of food, (3) proportion of litter, and (4) method of management and age. Ordinary barnyard manure properly cared for may be assumed to contain on the average one-half per cent each of nitrogen and potash and one-third per cent of phosphoric acid.

Mature animals, neither gaining nor losing weight, excrete practically all the fertilizing constituents consumed in the food. Growing animals may excrete as little as 50 per cent of the fertilizing constituents of the food, milch cows excrete from 65 to 85 per cent, fattening or working animals from 85 to 95 per cent. As regards the fertilizing value of equal weights of manure in its normal condition, farm animals probably stand in the following order: Poultry, sheep, pigs, horses, cows.

The term farm manures in its broadest sense is used to designate all materials (not included under green manures and commercial fertilizers) that may be made or accumulated on a farm, and which can be used for improving the fertility of the land, but the term is most commonly used to designate the excrements of domestic animals.

The term stable manure is used to designate manure just as it comes from the stables, and which is used in the fresh state. Yard or barnyard manure is the term applied to manure which has accumulated, or been kept for some time in a pile in the barnyard. The name of fresh manure is applied to manure that is only a few hours old, and as it comes from the stable. Rotted manure is the name used to designate manure that has gone through considerable fermentation, and more or less disintegrated. Mixed manure is the excrements of different species of animals, with the bedding or other material thrown together. Manure from a single species of animal is designated by the kind of animal producing it.

Perhaps one of the chief sources of profit on a well kept farm is the manure obtained from stock. No farmer is desirous of farming economically who neglects this very important matter. Unless properly cared for, manure is sure rapidly to lose much of its value.

All manure does not possess the same agricultural value, neither does the excrement from one animal possess the same value at different times. The manure from a well fed animal is much more valuable than that from a poorly fed one. The droppings of a half starved animal possess little value as a fertilizer. It is hardly profitable to use, but when the animal has been well fed, on a rich diet like cotton-seed meal or wheat bran, it has been proven that the plant food locked up in the animal manure is more valuable from a money standpoint than was the food itself when purchased in the market. When fed to stock, cotton-seed meal is known to produce a manure of excellent quality. These seeds are now used in immense quantities as a source of nitrogen in the manufacture of commercial fertilizer, but it would be much better for the farmer who grows his seed to exchange them for an equal weight of hulls and meal. The manufacturer is generally willing to make this agreement, and finds his profit in the oil collected from pressing the seed. Upon the other hand, the oil in the seed has no fertilizing value, and, in this way, the farmer would gain more real plant food by making the exchange. Then by purchasing phosphoric acid and potash, and mixing them with the meal, he will have another complete fertilizer to supplement his store of barnyard manure.

Barnyard manure is one of the most efficient means at the disposal of the farmer to permanently improve his soil. Probably no other fertilizer possesses to so great a degree the power of restoring worn soils to productiveness and giving them lasting fertility. It accomplishes this result, however, not so much by the actual fertilizing constituents which it supplies as by improving the physical properties of the soil, increasing the amount of humus, which is generally deficient in worn soils, improving its texture, and increasing its water-absorbing and water-holding power. Experiments have shown that the influence of manure may be perceptible twenty years after application. Observations at Rothamsted, England, during forty years on barley unmanured, manured continuously, and manured during the first twenty years only showed that there was gradual exhaustion and reduction of produce without manure, and gradual accumulation and increase of produce with the annual application of farmyard manure. But when the application was stopped, although the effect of the residue from the previous applications was very marked, it somewhat rapidly diminished, notwithstanding that calculation showed an enormous accumulation of nitrogen as well as other constituents.

Feeding-stuffs contain plant food. After they are used by the animal, most of the plant food is excreted by the animal in the solid and liquid excrement. A small portion is retained by growing animals, and a portion is used by cows in the elaboration of their milk, but the largest part passes off. The plant food in the excrement is equally as valuable as that in the food, pound for pound. The farmer who feeds cottonseed meal and wastes the manure gets only the feeding value of his feed. One who buys cottonseed meal for use as a fertilizer gets only its fertilizing value. But one who feeds the meal and saves the manure secures both the feeding value and a portion of the fertilizing value of the feed. How much of the fertilizing value he may secure, depends upon the success with which loss is prevented, but since cottonseed meal has a fertilizing value of about $28 a ton, one who feeds meal and saves the manure should get at least $15 a ton more value from his meal than one who uses the meal for fertilizing purposes only, or who feeds the meal and wastes the manure.

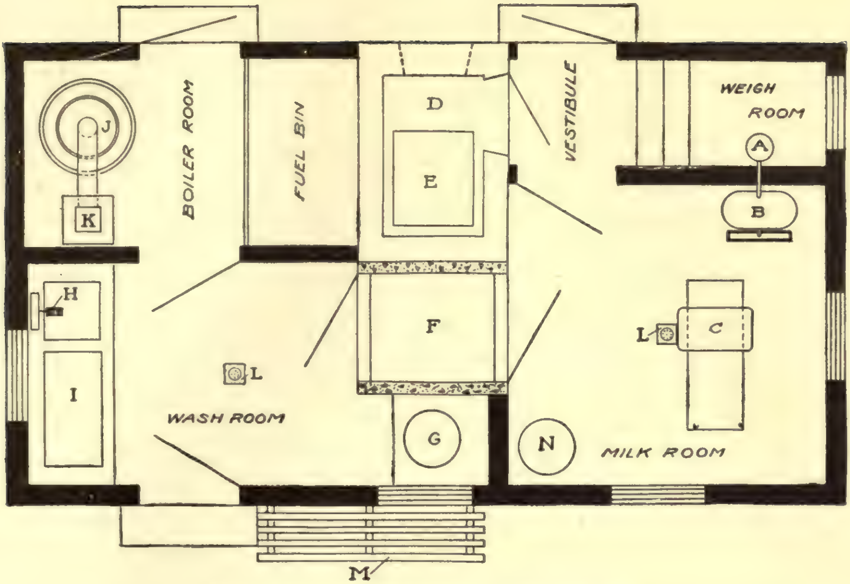
The value of stable manure depends on the system of feeding practiced, the kind of animals kept, and the method of caring for and applying the manure to the land. Rich feeding produces rich manure, since the most valuable farm foods are almost without exception very rich in fertilizer ingredients. The amounts of the fertilizer elements retained by farm animals in the body or made use of in their products will vary with different animals and with the same animals at different periods of growth. Milch cows will void in the excrements about 75 per cent of the nitrogen, and about 90 per cent of the ash constituents contained in the food. Young growing animals will give somewhat similar quantities, while fattening animals will void about 90 per cent of nitrogen, and 96 per cent of the ash materials in the liquid and solid excrements. We may assume that on the average at least four-fifths of the nitrogen and nine-tenths of the other fertilizer elements in the feeds eaten will be obtained in the manure of farm animals.

The following table, showing the amounts of fertilizing constituents in 1 ton of different agricultural products, indicates directions in which such an exchange may be effected with advantage:

Manurial Constituents Contained in 1 Ton of Various Farm Products.

Farm product.	Manurial constituents.		
	Nitrogen.	Phosphoric acid.	Potash.
	Pounds.	*Pounds.*	*Pounds.*
Timothy hay	19.2	7.2	25.2
Clover hay	39.4	8.0	35.0
Alfalfa hay	53.2	10.8	49.2
Cowpea hay	49.6	13.2	47.2
Corn fodder, field cured	17.2	7.2	21.4
Corn silage	8.4	2.4	6.6
Wheat straw	8.6	2.6	14.8
Rye straw	10.0	5.8	15.8
Oat straw	13.0	4.4	24.4
Wheat	34.6	19.2	7.0
Rye	32.4	16.2	10.4
Oats	36.2	15.4	11.4
Corn	29.6	12.2	7.2
Barley	39.6	15.4	9.0
Wheat bran	51.2	58.4	31.4
Linseed meal	108.6	37.6	26.2
Cotton-seed meal	142.8	61.8	36.4
Potatoes	7.0	3.2	11.4
Milk	10.2	3.4	3.0
Cheese	90.6	23.0	5.0
Live cattle	53.2	37.2	3.4

The exchange of 1 ton of corn for 1 ton of wheat bran, for instance, will result in a gain of 21 pounds of nitrogen, 46 of phosphoric acid, and 24 of potash. With an exchange of milk or potatoes for the concentrated feeding stuffs the gain is still more striking.



Model for a Milk House. Dept. of Agr.

Range Land Inside and Outside of Fence Line, April 1905, showing Improvement Due to 2 Years' Protection by Fencing. Dept. of Agr.

The amounts of fertilizing constituents in the manure stand in direct relation to those in the food. As regards the value of manure produced, the concentrated feeding stuffs, such as meat scrap, cotton-seed meal, linseed meal, and wheat bran, stand first, the leguminous plants (clover, peas, etc.) second, the grasses third, cereals (oats, corn, etc.) fourth, and root crops, such as turnips, beets, and mangel-wurzels, last.

The nitrogen of the food exerts a greater influence on the quality of the manure than any other constituent. It is the most costly fertilizing constituent. It undergoes more modification in the animal stomach than the mineral constituents (potash and phosphoric acid), and rapidly escapes from the manure in fermentation. The secretion of urine increases with the increase of nitrogenous substances in the food, thus necessitating the use of larger amounts of litter and affecting both the amount and value of the manure. The use of watery foods, as is obvious, produces the same result.

Farm Manures as a Source of Plant Food.—While the composition of farm manure varies with the conditions already enumerated, yet they all supply more or less of the essential plant foods—nitrogen, phosphoric acid (phosphorus) and potash. The average mixed farm manure contains these plant foods in the proportion of approximately ten parts of nitrogen to six parts of phosphoric acid and eight parts of potash. Mixed stable manure contains on the average about 0.50 per cent. nitrogen, 0.30 per cent. phosphoric acid, and 0.40 per cent potash. All manures contain as a rule both the dung and urine of animals, mixed with some absorbents. The dung consists chiefly of the undigested portions of the food consumed, which was first ground fine by the teeth, and then saturated and softened with the water and digestive fluids of the alimentary canal. This dung, while composed largely of the woody tissues of the food eaten, yet, being very fine and soft, will decompose and give up its plant food very readily. Dung contains approximately one-third of the total nitrogen, one-fifth of the total potash, and nearly all of the phosphoric acid voided by animals. The plant foods in dung are not soluble and must be decomposed before they can be utilized by plants. The urine of domestic animals contains compounds which have been formed in the body. It usually contains about two-thirds of the total nitrogen, four-fifths of the total potash, and very little of the phosphoric acid voided by the animal. While the elements found in the urine are in solution, yet they are not immediately available as food for plants, but become so much more quickly than the constituents found in the dung.

In practice it has been found that while farm manures furnish some of all of the essential plant foods, yet it is considered unbalanced, as it does not supply them in the proportions found most satisfactory in practice. This is due to the fact that soils gain nitrogen through other sources, and that the potash in soils becomes available through various means more rapidly than the phosphoric acid.

Physical Effects of Manures.—As all farm manures contain a considerable percentage of organic matter, they have a marked influence in producing a better physical or mechanical condition in the soil to which they are applied. In fact, this value of improving the texture is often far greater than that derived from the plant food supplied.

In another connection it has been pointed out that many farm soils, even those that are unproductive and apparently worn out, contain large amounts of plant food; and that this can be largely corrected by improving the mechanical condition or texture.

When manure is incorporated with a soil it greatly improves the texture, loosening a heavy, compact soil, and binding together a light, leachy one, making the soil more friable, warmer, more retentive of moisture, and more congenial to plants in every way. Some experiments conducted by King, at Wisconsin Station, showed that manured land contained 18 tons more water per acre in the upper foot of soil than similar land unmanured, and 34 tons more in the soil to a depth of three feet. Manure exerts a quicker beneficial influence on the texture of soils than green manures. Manures will also aid in equalizing the supply and distribution of water in the soils; will make soils to which they are applied darker in color, and exert a material influence in making soils warmer. Manured land is less subject to the denuding effects of wind and rain.

Chemical Effects of Manures.—Manures act chemically on soils, as already stated, by adding new stores of plant food, and by their decomposition in the soil they give off carbonic acid gas, which unites with the soil waters and increases its dissolving action on mineral plant foods. It also provides the formation of humates in the soil, and thus renders inert mineral plant food more available. The temperature of soils will be materially raised as a result of the chemical actions.

Bacterial Influences of Manures.—In addition to supplying plant food and vegetable matter, with their accompanying benefits, farm manures introduce into the soil a variety of bacteria and ferments, which also produce beneficial results. These bacteria, though great in number, have not been studied much in detail, and are little understood. It is very certain, however, that they are helpful in increasing the supply of available plant food. Farm manures have often the advantage over green manures in that the ferments introduced by the manure will result in an alkaline condition of the soil, while that from the green manure will be acid. Hence manure favors the nitrogen-gathering bacteria of legumes and nitrifying organisms.

Professor Chester of the Delaware Experiment Station, has found in a soil that had been liberally manured, and was producing at the rate of six tons of hay per acre several times as many bacteria as were found in the same soil which had little manure, and was producing about one ton of hay per acre.

Factors Influencing the Value of Manure.—The factors which influence the commercial and agricultural values of stable manures depends upon the following: (a) The kind of animals; (b) the age and condition of the animal; (c) the food of the animal; (d) the kind and quantity of absorbents used; (e) the management of the manure.

Each species of domestic animal produces a manure of different quality, and with distinct characteristics. The most marked difference, as noted by its composition, is in the amount of water and organic matter which they contain.

Cattle Manure.—Cow or steer manure contains considerably more water than that from other domestic animals. It ferments and heats slowly, and is ranked as a cold manure. A cow will produce 40 to 50 pounds of dung or solid manure per day, and 20 to 30 pounds of urine or liquid excrement. A cow fed a balanced ration will void about one-half of the nitrogen in the urine, about one-fourth in the milk, and the balance in the solid excrements.

Horse Manure.—Horse manure contains less water than cattle manure, and as the horse has less power to digest cellulose, the manure is more fibrous. Horse manure ferments easily, and hence is called a hot or quick manure. In fermenting, horse manure gives off ammonia or nitrogenous products, and rapidly deteriorates in quality. Because of the rapid fermentation of horse manure, it easily becomes dry and fires. To prevent fire-fanging and loss through fermentation, horse manure, when in piles, should be kept very compact and moist. Mixing horse manure with cow manure will aid in preserving it, and contribute to the value of both for general purposes. The quality of quick fermentation and heating makes horse manure especially valuable for use in hotbeds, mushroom beds and for cold, wet soils. Horse manure is more bulky, or weighs less per cubic foot, than cow manure. A well-fed horse will produce about fifty pounds of manure per day, about one-fourth of which is urine.

Hog Manure.—Hog manure is a wet, cold manure. It ferments slowly. Its composition varies considerably, depending upon the food consumed. It is much like cow manure in its general characters, but usually much richer. A pig produces 10 to 15 pounds of manure per day.

Sheep Manure.—Sheep manure is usually richer and dryer than that from any other domestic animal except poultry. It ferments easily, and is classed as a quick-acting manure, but keeps well when allowed to accumulate in pens where it is tramped hard by the animals. When placed in piles or composts it is benefited by mixing with cow manure. It is especially valuable for use on flowers or vegetables, when a quick-acting manure is desired. A sheep produces about four pounds of manure per day.

Poultry Manure.—Poultry manure is the richest of farm manures, but, like all others, it is variable in composition. It is rich in all the fertilizing elements, but especially so in nitrogen, which is due in part to the fact that the urinary secretions are semi-solid, and voided with the solid excrements. Poultry manure ferments easily, and is quick acting. It loses nitrogen and ammonia very easily, if not properly cared for. It should be kept dry, and if possible also mixed with some absorbent and preservative. Acid phosphate, phosphate rock, plaster and dry earth are good materials for this purpose. Hardwood ashes, ordinary slaked lime, and such alkaline materials should be avoided, as they will liberate the ammonia, and cause it to be lost. A hen will produce 30 to 40 pounds of manure per year, and a turkey 40 to 60 pounds.

Average Yield and Composition of Fresh Excrements of Farm Animals.

DUNG—SOLID EXCREMENTS.	Excreted per Year.	COMPOSITION.			
		Water.	Nitrogen.	Phosphoric Acid	Potash Soda
	Lbs.	%	%	%	%
1. Cows	20000	84.0	0.30	0.25	0.10
2. Horse	12000	76.0	0.50	0.35	0.30
3. Pigs	1800	80.0	0.60	0.45	0.50
4. Sheep	760	58.0	0.75	0.60	0.30
5. Hen	....	48.6	1.38	0.50	0.41
URINE—LIQUID EXCREMENTS					
1. Cows	8000	92.0	0.80	Trace.	1.4
2. Horse	3000	89.0	1.20	Trace.	1.5
3. Pigs	1200	97.5	0.30	0.12	0.2
4. Sheep	380	86.5	1.40	0.05	2.0

The quality of manure is materially influenced by the age, condition and uses made of the animal. An animal which is making growth will yield a poorer manure than animals similarly fed that have completed their growth, as the materials for forming bone, muscle, blood, etc., must be extracted from the food. The elements chiefly affected are the nitrogen and phosphoric acid. Animals in poor condition, and being fed for the production of flesh, leave considerable less nitrogen in the manure than those in normal condition. Fattening animals produce a rich manure, as they are at rest and storing almost exclusively fat, which uses very little of the plant food elements. Animals that are bearing young, or are producing milk, eggs or wool, utilize considerable nitrogen and phosphates and some potash in their production, and the excrements are poorer in plant foods to that extent.

Miscellaneous Farm Manures.—There are a variety of materials that may be available as manure on many farms, and it is well for farmers to utilize them whenever possible. The ones most commonly met with are described below:

Night-Soil and Poudrette.—These are terms used to designate human excrements. The name night-soil probably had its origin from the fact that this material is usually handled in towns and cities during the night. The term poudrette has been given to the dried excrements which are manufactured in some places. In order to use night-soil to any advantage, it is best to compost it with some good absorbent, such as loam, muck or peat. It is estimated that the excrements of a man for one year contains about eleven pounds of nitrogen, two and one-half pounds of phosphoric acid and two pounds of potash.

Muck and Peat.—There are names used to designate partially decayed vegetable matter which has accumulated in marshes, swamps and shallow ponds. It is quite variable in composition, generally ranging from one-half to two per cent of nitrogen, and only traces of phosphoric acid and potash. They are quite valuable for use on sandy soils, and on very stiff clays. The better classes make good bedding and absorbents.

Leaf Mould.—This is a term applied to a more or less decayed accumulation of leaves in the woods. It is especially valuable for some special classes of gardening or truck crops. It is costly to gather, and its removal is more or less harmful to the forest trees. It contains about twenty pounds of nitrogen, three and one-half pounds of phosphoric acid, and twelve pounds of potash per ton.

Sea Weeds.—Along the sea border there is considerable quantities of sea weeds washed ashore from time to time, and most of these are fairly rich in plant food, and afford a good source of manure. They contain from 5 to 12 pounds of nitrogen, two to five pounds of phosphoric acid, six to twelve pounds of potash per ton.

Comparative Value of Solid and Liquid Parts.—It is a fact often lost sight of in practice that the urine of animals is by far the most valuable part of the excreta. In experiments with milch cows at the Pennsylvania Experiment Station it was found that the urine contained more than one-half of the fertilizing matter of the food and nearly two-thirds of that of the total manure (dung and urine). The solid manure (dung) contains, principally, the fertilizing constituents of the food which have failed to be digested or absorbed into the animal system and are, therefore, chiefly in insoluble forms. The urine, on the other hand, contains those fertilizing constituents which have been digested and are largely soluble. The composition of the urine, like that of the dung, varies with the kind and age of the animal, but especially with the nature of food, water drunk, etc. The composition of the urine of different kinds of farm animals has been found by analysis to be as shown in the following table:

Chemical Composition of the Urine of Different Animals.

	Water.	Nitrogen.	Phosphoric acid.	Alkalies
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Sheep	86.5	1.4	0.050	2.0
Swine,	97.5	.3	.125	.2
Horses	89.0	1.2	....	1.5
Cows	92.0	.8	....	1.4

The urine of farm animals is practically free from phosphoric acid except in the case of sheep and swine, the urine of which contains minute traces of phosphoric acid, but is rich in nitrogen and the alkalies (including potash and soda). In the experiments at the Pennsylvania Station, it was observed that the urine of milch cows contained about one-half of the nitrogen and three-fourths of the potash of the food consumed, but almost no phosphoric acid. The dung, on the other hand, contained about one-third of the nitrogen, one-sixth of the potash, and three-fourths of the phosphoric acid of the food. The remainder of the fertilizing constituents was found in the milk. In experiments with sheep at the Maine Experiment Station it was found that the urine contained nearly half the potash of the total excreta and from half to three-fourths of the nitrogen, but no phosphoric acid, the latter being wholly in the solid excrement. Urine used alone is, therefore, an incomplete fertilizer, and should, as a rule, be supplemented by phosphates. It is best, however, to apply it along with the dung, which contains a considerable amount of phosphoric acid, but much less potash than the urine. These facts help to explain why leachings from mixed manure are often more valuable as a fertilizer than either dung or urine alone. The leachings contain, in addition to the constituents of the urine, the soluble matter of the dung, in which there is a considerable amount of phosphoric acid. Mixing the solid and liquid manure insures a better balanced fertilizer as regards potash, as well as phosphoric acid. Experiments made at the New Jersey Station show that the potash of cow dung varied from 0.13 to 0.27 per cent; in mixed dung and urine from 0.28 to 0.73 per cent, the percentage of phosphoric acid in the mixed manure being substantially the same as in the dung alone. The comparative value of solid and liquid manure, as indicated by chemical composition, is shown in the following table:

Composition of Solid and Liquid Excrement of Farm Animals.

	Water		Nitrogen.		Phosphoric acid.		Alkalies (potash and soda).	
	Solid.	Liquid.	Solid.	Liquid.	Solid.	Liquid.	Solid.	Liquid.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Horses	76	89.0	0.50	1.20	0.35	Trace.	0.30	1.5
Cows	84	92.0	.30	.80	.25	Trace.	.10	1.4
Swine	80	97.5	.60	.30	.45	0.125	.50	.2
Sheep	58	86.5	.75	1.40	.60	.050	.30	2.0

The urine is seen to be much richer than the solid dung in every case except that of hogs, in which the high percentage of water (97.5) causes the percentages of the other constituents to fall below those of the same constituents in the solid dung. The fact that the urine of all farm animals (including hogs) is much richer than the solid excrement is strikingly brought out in the following table, which shows the composition of the dung and urine after the water has been completely removed:

Composition of Dry Matter of Solid and Liquid Manure.

	Nitrogen.		Phosphoric acid.		Alkalies (potash and soda).	
	Solid.	Liquid.	Solid.	Liquid.	Solid.	Liquid.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Horses	2.08	10.9	1.45	Trace.	1.25	13.6
Cows	1.87	10.0	1.56	Trace.	.62	17.5
Hogs	3.00	12.0	2.25	5.00	2.50	8.0
Sheep	1.78	10.4	1.42	.37	.71	14.9

The distribution of the manurial constituents in the urine and dung depends largely on the nature of the food. If the food is nitrogenous and easily digested the nitrogen in the urine will greatly preponderate; if, on the other hand, the food is imperfectly digested the nitrogen in the solid excrement may form the larger quantity. When poor hay is given to horses the nitrogen in the solid excrement will exceed that contained in the urine. On the other hand, corn, oil cake, and roots yield a large excess of nitrogen in the urine.

In general, therefore, it may be said that: (1) Of the nitrogen, phosphoric acid, and potash supplied in the food, comparatively small amounts are assimilated and retained in the animal body, the relation between the amounts of these substances excreted in the urine and the solid excrement depending largely upon the nature of the food. (2) The urine is much richer in nitrogen than the solid dung, usually containing one-half or more of the total amount excreted; it also contains a large proportion of the potash, but is poor in phosphoric acid, which remains almost entirely in the solid excrement. The best results may therefore be expected from applying the mixed solid and liquid excrement.

Influence of Age and Kind of Animal.—The proportions of the potash, phosphoric acid, and nitrogen of the food recovered in the manure vary considerably with the age and kind of animal. Full-grown animals, neither gaining nor losing weight, excrete practically all of the fertilizing constituents consumed in the food. Rapidly growing animals may excrete as little as 50 per cent of the fertilizing constituents of the food; while milch cows excrete from 65 to 85 per cent; and fattening or working animals from 90 to 95 per cent. The Mississippi Experiment Station found that young fattening steers excreted on an average 84 per cent of the nitrogen, 92 per cent of the potash, and 86 per cent of the phosphoric acid of the food consumed. The Pennsylvania Station reports experiments in which milch cows excreted 83 per cent of the nitrogen, 92 per cent of the potash, and 75 per cent of the phosphoric acid of their food.

It has been shown that both the amount and the value of manure vary to a considerable extent with the kind of animal producing it, the animals producing the smaller amounts as a rule yielding the richer manure. Thus, sheep which produce the smallest amount of manure per 1,000 pounds of live weight rank with hogs in yielding that of greatest value per ton, and cows which stand first as regards production rank lowest as regards quality. Hogs, however, stand in the front rank as regards both amount and quality of manure produced. These differences are explained to a large extent by the dissimilar feeding habits of the different kinds of animals.

Waste of Manure.—Even though manure is regarded highly by all farmers in sections where fertilizers are needed, nevertheless there is probably no product of equal value which is so much neglected and so poorly cared for. The first great source of loss is through the incomplete absorption of the urine. It is not infrequent to see no attempt being made to save this portion of the manure. When it is remembered that the urine is richer in both nitrogen and potash than the dung, and that they are more available to crops in the urine than in the dung, it should be self-evident to all that it is highly essential that this part of the manure be carefully saved.

The second greatest source of waste of manure is the loss incurred by leaching. If manure is piled against the side of the stable where the water from the roof can drip on it, or if it is piled on the hillside, or other exposed places, the rain water in leaching through the manure washes out of it much nitrogen and potash, which is seen in the dark-brown liquid oozing from the base of the pile.

The third common source of loss is that incurred by heating and fermenting. When manure is thrown in piles it soon heats and throws off more or less vapor and gas. This heating is caused by fermenting or breaking down of the materials composing the manure. The fermentation is caused by the action of bacteria or low orders of microscopic plants. The bacteria which produces the most rapid fermentation in manure need plenty of air or oxygen. Therefore, fermentation will be more rapid in loosely piled manure. A certain amount of moisture is necessary for fermentation, but if the manure is wet fermentation is checked, because it lowers the temperature, and excludes part of the supply of air. The fermentation which takes place in manure breaks down the organic matters, and cause a loss of humus, and also of nitrogen through the ammonium compounds, which are volatilized. The odor of ammonia, which is commonly noticeable about horse stables and piles of horse manure, is an evidence of the fermentation and loss which is taking place.

Fresh manure loses in the process of decay from 20 to 70 per cent of its original weight. An 80 ton heap of cow manure left exposed for one year lost 66 per cent of its dry substance. Some tests conducted by the Cornell Experiment Station showed that 2 tons of horse manure exposed in a pile for five months lost 57 per cent of its gross weight, 60 per cent of its nitrogen, 47 per cent of its phosphoric acid and 76 per cent of its potash. Five tons of cow manure exposed for the same length of time in compact pile lost 49 per cent of its gross weight, 41 per cent of its nitrogen, 19 per cent of its phosphoric acid and 8 per cent of its potash.

While manures may lose a large per cent of their valuable constituents, yet they may be worth more per ton than they were before the loss occurred; because the plant foods remaining are concentrated into a less quantity of material.

Where it is practicable to haul the manure from the stalls and pens and spread it on the field at short intervals, the losses of valuable constituents need not be very great, but when, as in winter, the manure must be stored for some time the difficulties of preservation are greatly increased.

Under these conditions, deterioration of manure results from two chief causes: (1) Fermentation, whereby a certain amount of the nitrogen is lost, and (2) weathering or leaching, which involves a loss of the soluble fertilizing constituents, including potash and phosphoric acid as well as nitrogen.

Fermentation of Manure.—The fermentation of manure is due to the action of minute microscopic organisms which belong to two great classes: (1) Those which require an abundant supply of air (oxygen) and which die when deprived of oxygen—known as aerobic ferments; and (2) those which grow without oxygen and die when exposed to it—known as anaerobic ferments.

The decomposition observed in the manure heap is due as a rule to the combined action of these two classes of ferments. On the outer surface of the heap, where the air circulates freely, the first class (aerobic) is active, while in the interior of the heap, where the supply of air is limited, the fermentation is due to the anaerobic ferments. The latter soon run their course and cease to exist. Their function seems to be principally to break up the more complex substances of the manure and prepare them for the further action of the aerobic ferments, which finally convert them into simpler compounds, such as water, carbon dioxid, and marsh gas.

Where the manure is compacted (as in deep stalls, for instance) the carbon dioxid formed by fermentation soon permeates the mass so completely as to entirely exclude the air, thus arresting fermentation. In loose heaps into which air is freely admitted fermentation of the aerobic form may go on indefinitely.

The fermentations of manure are very complex and vary according to circumstances. The principal conditions affecting these processes are (1) temperature, (2) supply of air as determined by compactness of heap, (3) moisture, (4) the composition of the manure, and (5) the nature of preservatives added.

The higher the temperature the more rapidly will manure decay. In aerobic fermentation of manure the temperature may rise to 122° to 140°, or even 158° F. On the other hand, in the interior of the heap, where anaerobic fermentation is in progress, the temperature rarely rises above 95° F. Experiments have indicated that 131° F. is the most favorable temperature for manure fermentations.

As already explained, the supply of air determines whether the slow-acting anaerobic ferment or the more vigorous aerobic ferment predominates. The careful regulation of the two kinds of fermentation is necessary to the successful rotting of manure. If the heap is too loosely built the decomposition is too rapid; the materials useful for the formation of humus in the soil are destroyed, and the nitrogen, especially that of the urine, escapes into the air, partly as ammonia, partly as free nitrogen. On the other hand, if the manure is too firmly packed the decomposition may be too slow and the manure will not become sufficiently disintegrated to produce the best effect in the soil.

It has been found that barnyard manure contains in large numbers microscopic organisms which cause denitrification—that is, they decompose nitrates and set the nitrogen free in the gaseous form. For this reason nitrates are not found in fermenting manure and should not be mixed with it. It has even been asserted that the application of manure may result in considerable losses of nitrogen from the nitrates of the soil from this cause, but recent experiments make it clear that such losses occur, if at all, only in case of excessive applications of manure, and that on the other hand ordinary applications of manure favor nitrification, or the formation of nitrates, in the soil.

A powerful means of controlling fermentation is the supply of moisture. The addition of water lowers the temperature and thus retards fermentation. By filling up the pores of the mass and excluding the air it checks aerobic fermentation when this becomes too active. French authorities maintain that the principal precautions necessary to prevent losses of ammonia consist simply in regularly and properly watering the manure with the leachings. In case of drought, if the leachings are insufficient, the lack should be made up with water.

The need of keeping manure moist is especially marked in case of horse manure, which is naturally dry and decomposes with great rapidity. The same is true in a less degree of sheep manure. The common and harmful fire-fanging is the result of an insufficient supply of water and may be readily checked by sprinkling. The sprinkling, however, should be regularly done and the heap kept in a constant state of moisture, otherwise the alternate wetting and drying will result in a loss of ammonia. Preservation of manure in this manner is generally practiced in Europe, and the product obtained is highly esteemed as a fertilizer. It is very dark colored, or even black, and acquires a highly offensive odor, while the straw in it loses its consistency and becomes soft and incoherent. This black substance is held by certain French agriculturists to possess special value as plant food. A method employed in the preparation of this well-rotted manure in France is as follows: The manure is placed on slightly inclined plats of packed earth or cement, so arranged that the leachings drain out into a pit, from which they are pumped up and distributed over the manure heap. It is usual to provide two manure plats, so arranged that when one is full (when the manure is 8 to 10 feet high) it may be allowed to ferment undisturbed while the other is used.

It has been questioned whether the construction of expensive cisterns for collecting the manure leachings repays the cost, but it is obviously desirable from what has been said regarding the value of the liquid manure and the desirability of promoting regular and uniform fermentation of the manure that the leachings should be saved and added to the manure heap by some means. Stored separately, the liquid part rapidly deteriorates and the solid part, from lack of moisture, is liable to undergo fire-fanging or harmful fermentation.

The nature and extent of fermentation in manure also depends to some extent on the composition of the manure, more particularly upon the amount of nitrogen in a soluble form which it contains. The greater the amount of soluble nitrogen the more rapid the fermentation. Urine, as we have already seen, is rich in soluble nitrogenous compounds, and this explains why it decomposes so rapidly.

By fermentation manure decreases rapidly in bulk. The substances of which it is composed are converted largely into water and gases, principally carbon dioxid, and where fermentation is not properly controlled, nitrogen may escape either in the free gaseous state or as ammonia. The coarse materials of the manure are gradually decomposed and are dissolved to a considerable extent in the black liquid which oozes out of the manure heap. As already shown the mineral matter (phosphates, potash, etc.) is also rendered more soluble. When properly controlled, therefore, fermentation is a valuable means of increasing the availability of the fertilizing constituents of manure, although it decreases the bulk; but when not properly controlled it seriously reduces the value of the manure.

Leaching of Manure.—Leaching is the second cause of deterioration of manure. When manure is exposed to the action of the elements and the leachings allowed to drain away it rapidly decreases in value. Both the organic and the mineral constituents originally present, or which have been made soluble by fermentation, are carried off and lost. Experiments at the New York Cornell Experiment Station indicated that horse manure thrown in a loose pile and subjected to the action of the elements will lose nearly one-half of its valuable fertilizing constituents in the course of six months; and that mixed horse and cow manure in a compact mass and so placed that all water falling upon it quickly runs through and off is subjected to a considerable, though not so great, loss.

The Kansas Station concludes from similar observations that farmyard manure must be hauled to the field in spring, otherwise the loss of manure is sure to be very great, the waste in six months amounting to fully one-half of the gross manure and nearly 40 per cent of the nitrogen that it contained.

In more recent experiments at the New Jersey stations solid cow dung exposed to ordinary leaching for one hundred and nine days lost 37.6 per cent of its nitrogen, 51.9 per cent of its phosphoric acid, and 47.1 per cent of its potash. Mixed dung and urine lost during the same time 51 per cent of its nitrogen, 51.1 per cent of its phosphoric acid, and 61.1 per cent of its potash. In brief, more than one-half of the constituents in the total animal manure product of the cow may be lost by an exposure of less than four months.

In experiments at the Canada Experimental Farms a 4-ton lot of horse manure (with litter) kept in an open bin lost one-third of its nitrogen, one sixth of its phosphoric acid, and a little more than one-third of its potash in one year. A similar lot of manure kept in a closed shed lost only one-fifth of its nitrogen and practically no phosphoric acid and potash.

The unavoidable mechanical losses of stable manure occur through dropping manure on or outside the farm where it cannot be recovered. These losses cannot, of course, be entirely eliminated except through permanent stabling of the animals, a system that is only practiced in case of dairy cows in some sections and which cannot be recommended under the conditions of farming present in this country. The losses occurring through avoidable sources are, however, greater than many farmers realize; at a conservative estimate not more than one-half of the fertilizer value which manure contains is preserved and contributes to make good the losses of plant food in the soil from the culture of grain and other crops. Careful trials by several experiment stations have shown that the losses of fertilizer constituents in the manure under ordinary conditions of piling and exposure during the summer months alone amount to from 30 to 50 per cent. These losses may be largely avoided by protecting the manure from leaching and from fermentation, the two great causes of its deterioration.

The liability of manure to a rapid loss of its constituents, and consequently the important bearing of proper handling upon the actual value of the product made, are not so fully recognized as they should be. It follows, too, from the general character of the material, that the richer the original manure is in the essential fertility constituents, nitrogen, phosphoric acid and potash, the greater is the liability to loss, first, because of the greater tendency to rapid fermentation of a substance rich in nitrogenous substances, which results in a loss of nitrogen, and second, because of the greater possibility of loss from leaching in substances containing large amounts of soluble mineral salts. Farm manures are really nitrogenous in their character, for the chief valuable constituent is nitrogen; in average manure, valuing the constituents by commercial methods, the nitrogen would be worth twice as much as the minerals, phosphoric acid and potash, hence the losses liable to occur through fermentation affect the most expensive constituent, the one which probably contributes more to the maintenance of condition in soils than do the minerals.

Preservation of Manure.—Manure cannot be so handled as to prevent all loss of constituents before they are applied to the land, because the changes take place so rapidly. The greatest losses are liable to fall upon the combined solid and liquid, hence the greatest care should be exercised to prevent conditions which favor such loss. An effective way to preserve for the soil most of the valuable constituents of the manure is to haul it directly from the stalls to the field. This method is followed on many of the large dairy farms. If there is no sod on which to haul manure in wet weather, it is well to have a cemented pit under cover, in which to place the manure until it can be hauled to the field. When the ground is frozen in winter, manure can be spread on almost any field. Generally speaking, it should be spread on the field next to be plowed. The above method of handling manure gets both liquids and solids on the land. If any leaching occurs, let it be into the soil where the leachings will do the most good. Recent investigations indicate that when liquid manure is applied to the soil, the plant food in the manure is absorbed and held in the soil, and is not immediately washed out if not made use of by the plants.

The first step to be taken in the care of manure so as to prevent the losses mentioned above is to provide sufficient bedding or litter in the stable to absorb and save all the liquid parts. The losses due to fermentation can be greatly checked by mixing horse manure with the cooler cow manure, by making the piles compact so as to exclude the air and by moistening the pile so as to assist in excluding the air and also to lower the temperature. The use of chemical or mechanical absorbents such as plaster, kainit, phosphate rock, etc., in the stable and sprinkled over the manure assists in preserving the manure and preventing loss. Losses from washing or leaching by rain may be prevented by piling under cover or in favorable basin-like places, or still better by hauling it directly to the field and spreading it as soon as produced.

In order to reduce the loss in manure to a minimum, and also to economize in handling it, the general aim and practice should be to haul it directly from the stable to the field and spread it at once. On the average farm the following of this practice all through the year would result in less loss than any method that could be pursued. The use of rotted manure rather than fresh manure is desirable in connection with many market garden or vegetable crops, as it gives quicker results and with root crops will give a smoother and nicer product.

Manure should be spread as soon as it is hauled to the field. The practice of putting it in piles is objectionable because of the loss that is likely to occur. The placing in piles also involves additional labor. The manner of spreading will depend upon local conditions, but where the distance to haul is relatively short and it is desired to have it evenly spread the manure spreaders will be found serviceable machines. From 10 to 20 tons of manure per acre is usually considered a fair application; but considerable more is frequently applied for market garden crops. Experiments have shown that generally it would be far more profitable to use about one-half the usual quantities and to supplement it with commercial fertilizers.

The true fertilizing value of barnyard manure and the best and most economical methods of managing it have claimed much attention recently from a number of the foremost agricultural scientists of the world, and the conclusions they have reached are of great practical importance, for although the use of such manures is almost as old as agriculture itself, there are many questions related to their management and use which have never been clearly understood. It is well known that barnyard manure, if neglected, rapidly loses the greater part of its fertilizing value and becomes practically worthless, except to improve the mechanical and physical properties of the soil. It is also well understood by practical men that it is not economical to follow many of the elaborate methods of preservation which have been suggested. To be economical, the method of management must be simple and involve as little labor and expense as possible. The recent studies of scientific men on farm manures have been very largely directed to the very desirable practical end of simplifying methods of management and preservation.

Since the direct fertilizing value of manure depends so largely upon the nitrogen which it contains, the more important of these investigations have taken into consideration mainly the availability, changes, and causes and prevention of loss of this substance. It has been shown that there is a wide difference between the fertilizing value of the nitrogen of the solid liquid parts of the manure. The effectiveness of the former has been found in experiments to be only 10 per cent of that of nitrate of soda, while the latter was 90 per cent, being very nearly equal to that of sulphate of ammonia. The nitrogen of the solid excrement becomes available very slowly in the soil or in the heap, while that of the urine is in a soluble form, rapidly converted into ammonia which may escape into the air. Experiments are recorded which indicate that the effectiveness of the nitrogen of the solid excrement is not materially increased by mixing it with the liquid part, the nitrogen of such a mixture being decidedly less available than that of either nitrate of soda, sulphate of ammonia, or green manures. The conversion of the nitrogen of the urine into ammonia, moreover, is apparently hastened by the admixture of solid excrement and straw.

Careful attention to the construction of the manure heap so that air will be as completely excluded as possible, keeping the heap moist, and avoiding alternate wetting and drying have been suggested as means of preventing loss of valuable fertilizing constituents and of promoting a decomposition which will largely reduce the power of the manure to convert available nitrogen into less valuable or useless forms (denitrifying power) in the soil. Here we have an explanation of the effectiveness of well-rotted manure. Not only is the availability of its own nitrogen increased, but its power to injuriously affect available nitrogen from other sources is reduced.

Authorities agree that attention to the construction and management of the manure heap is much more important than the use of preservatives, with which the results have been contradictory. Kainit has been found to be effective in checking the formation of ammonia, and superphosphate in preventing its escape. The use of these is to be recommended where they can be cheaply obtained, because, in addition to preserving the manure, they add to it constituents (potash and phosphoric acid) in which it is somewhat deficient. Caustic lime has been found effective in destroying the denitrifying power of manure, above referred to, but there are certain serious objections to its use. It is well known that it has a tendency to drive off ammonia from organic matter such as manure. However, if the lime is applied to the fresh manure, the danger of loss from the escape of ammonia has been found to be very small. It is only after fermentation has commenced in the manure that the danger of loss on application of lime becomes serious. It has been suggested that it might be safe and economical to mix caustic lime or marl with the manure to destroy its denitrifying power and to cover the heap with earth to prevent the escape of ammonia. A second objection to lime is that it tends to convert the available nitrogen of manure into insoluble and less available forms, but this tendency is, in a measure, compensated for by the fact that, in addition to destroying the denitrifying organism, as already explained, the lime promotes nitrification, or the formation of nitrates, when the manure is applied to the soil. Lime should not be used in connection with superphosphate, because it renders the phosphoric acid which the latter contains insoluble and destroys the effectiveness of the superphosphate as a preservative.

Bisulphid of carbon almost entirely destroys the denitrifying organism, but its use in practice is not recommended because of its expensiveness. Sulphuric acid has proved very effective, not only preserving the fertilizing constituents but increasing the availability of the nitrogen, but its general use can hardly be recommended.

One point which has been clearly brought out by recent investigation is that the addition of straw may very decidedly reduce the fertilizing value of manure, the injurious effect being greater the larger the amount of straw used. This is explained by the fact that straw contains organisms which convert the available nitrogen in manures and in the soil into forms which the plant can not utilize. The excessive use of straw as litter under animals should therefore be carefully avoided if the most effective manure is desired.

A small amount of gypsum (land plaster) sprinkled on the moist dung or urine is commonly used as a means of fixing the ammonia. Kainit and acid phosphate (superphosphate) have also been recommended as preservatives of manure, but recent experiments indicate that none of these substances is of much value for preventing loss of nitrogen, which is the main object of the use of preservatives. In fact, the investigators who have given the most attention to the subject of the preservation of manure are generally disposed to attach much more importance to the proper use of absorbents and to keeping the manure heap compact and uniformly moist than to the use of preservatives. If kainit and acid phosphate are used they will increase the value of the manure by adding potash and phosphoric acid. If applied in the stall they should be covered with litter so that they do not come in contact with the feet of the animals.

In cases where different kinds of animals are kept, one of the most effective means of securing moderate and uniform fermentation of the manure heap is to see that the moist cold cow and pig manure is intimately mixed with the dry hot horse and sheep dung. The former makes the heap more moist and checks the too rapid fermentation and fire-fanging of the latter.

It thus appears that in order to reduce the loss to a minimum, manure heaps should be made compact and kept uniformly moist. Under cover the last result is secured by collecting the liquid manure and at frequent intervals sprinkling it over the heap, or when the supply of this is deficient, by sprinkling with water. Where the manure heap is exposed to the rain in pits from which there is no drainage it probably does not require so much attention, but still care must be taken to prevent loss by alternate leaching when heavy rainfalls occur and drying out in time of drought.

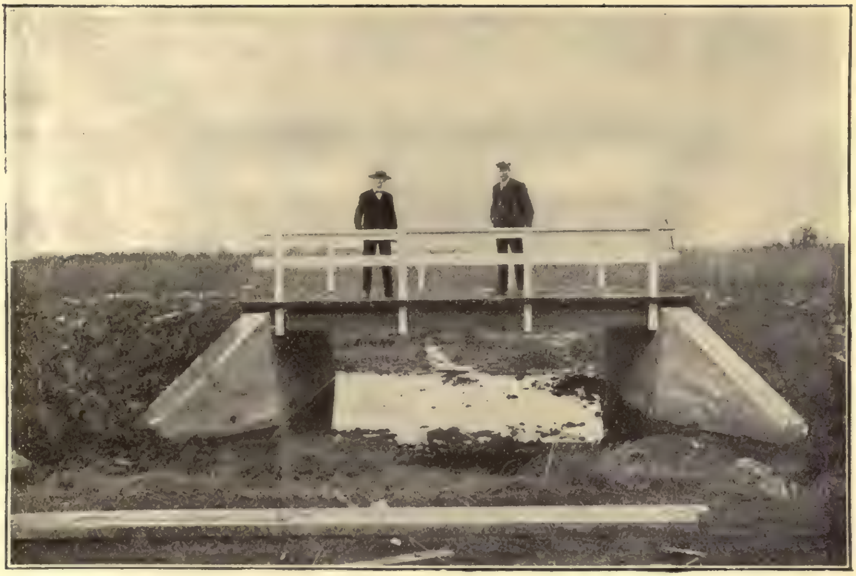
To secure such kind and degree of rotting as shall make the manure easily handled and put it into the condition best suited to the crops it is to fertilize, both extremes of moistness and cold, and of exposure and heat, are to be avoided.

It is a much-discussed question whether this mean condition is best obtained in practice by the preservation of the manure in dished yards, subject to more or less exposure to wind and sun, to full exposure to rain, but to more loosely leaching, or under covered sheds where it is protected from sun and rain, and largely from wind. In both cases it is supposed to be compacted fully as the heaps are forming.

The use of completely covered barnyards for protecting manure has in recent years met with much favor in certain parts of the country. The manure from the horse and cattle stables and the sheep and calf pens is spread out evenly over these yards, covered with coarse litter, and the whole kept firmly packed by allowing animals to run over it, thus preventing injurious fermentation.

Many stables are so situated that by adding a cheap lean-to a receptacle for caring for the manure is easily provided. The outside boarding of the lean-to should be, for a part of the way at least, put on horizontally and hung in the form of flat doors, so that the manure can be easily loaded on a wagon standing on the outside of the building.

The unsatisfactory results attending the use of manure sheds and covered yards have probably been due to the fact that these structures have generally been loosely constructed, allowing the free circulation of air, which has dried out the manure. We have already seen the losses caused by dry fermentation. On this account barn cellars, so common in New England, possess decided advantages as receptacles for manure. The common practice of allowing swine to work over the manure in these cellars is a wise one, since it mixes the manure and keeps it well packed and moist. In fact, if these cellars are provided with impervious bottoms to hold the liquid manure, this system of storing manure is very efficient.



Culvert with Substantial Abutments and Wing Walls. Dept. of Agr.
(See pages 149–165.)

Fallow Soil in Utah. Showing Desired Condition of Surface After Crust is Broken. Dept. of Agr.
(See page 42.)

Bedding.—Many materials are used for bedding, and these affect the value of the manure. The objects sought in materials used for bedding are as follows: (1) To make the animals a comfortable bed, and keep them clean; (2) to absorb and retain the urine and watery manure; (3) to dilute and improve the mechanical condition of the manure, and make it easier to handle. The materials used for bedding are generally not rich in fertilizing constituents, and to some extent tend to dilute the manure; but as they absorb and hold the valuable liquid parts, which are easily lost, they really improve the quality. Straw is the most universal bedding material in use, and it fulfills most of the requirements very satisfactorily. It is abundant on most farms, as it is in a measure a waste or by-product, and has no market. There are many other materials that have better absorbent powers than straw, and are relatively cheaper when bedding must be purchased.

Dust Absorbents.—In order to help absorb liquid manures, and prevent the loss of volatile ammonia compounds, dust absorbents are used. Good materials for use in this way are land plaster (gypsum), kainit, finely ground phosphate rock and phosphate, fine earth and sand.

The use of such materials as furnish phosphoric acid and potash are especially valuable, as they enrich the manure in these plant foods.

It is not advisable to use an excess of litter beyond that required to keep the animal clean and absorb the liquid excrement, since the materials available for bedding are as a rule poor in fertilizing constituents, and so extend and dilute the manure unnecessarily.

Combining Barnyard Manure With Other Materials.—It has been the general experience that probably the best way to utilize barnyard manure is in combination with such materials as supplement and conserve its fertilizing constituents. It has already been pointed out that certain substances, such as kainit and superphosphate, which are sometimes employed as preservatives, may also be used to advantage to improve the fertilizing value of the manure, but it is necessary to do more than this if a well-balanced fertilizer is desired, for, as has been shown, barnyard manure considered simply as a supplier of nitrogen, phosphoric acid, and potash is comparatively poor. The proportions of potash and phosphoric acid especially are low. The potash, however, is in a very available form and does not need to be re-enforced to the same extent as the much less available phosphoric acid.

Although nitrogen is one of the most abundant constituents in manure, it has been found that in order to get the best results in general it should be re-enforced if prompt action is desired. This is explained by the fact that a large part of the nitrogen of manure is very slowly available.

The nitrogen of farmyard manure must obviously exist in very different conditions. That due to the urine of animals will be most rapidly available, that in the finely divided matter in the feces will be much more slowly available, and that in the litter still more slowly available. Hence, the small proportion that is at once effective and the very large amount that accumulates within the soil in a very slowly available condition.

Experiments at Rothamsted, as well as at the New Jersey Station, indicate that the nitrogen of barnyard manure is much less available, weight for weight, than that of sulphate of ammonia, the availability varying widely, however, with the character and treatment of the manure.

What has been said about supplementing barnyard manure with more concentrated fertilizing materials should not be taken to imply that the two kinds of fertilizers should necessarily be composted or applied at the same time. In fact, as already pointed out, nitrates should never be composted with manure on account of the danger of loss of nitrogen through denitrification. It may be desirable to apply the manure at intervals of several years, while the concentrated fertilizers would need to be applied annually. However this may be the facts above given should be borne in mind in applying the supplementary fertilizers.

Whether the farmer can afford to incur the necessary labor and expense involved in the preparation of composts is a question on which there is considerable difference of opinion. This is a matter which must be determined largely by individual needs and conditions, but undoubtedly the manure heap may be utilized to advantage for such purposes as reducing bones and other waste products of the farm and for killing cotton seed before it is applied to the soil.

The fermenting of peat with stable manure was formerly practiced to a considerable extent. Where such a compost is desired the materials should be laid down in alternate layers in the proportion of about five parts of peat to one of manure.

The Compost Heap.—Composting manure is not usually economical where general farming is done. It requires too much labor; besides, the manure will ordinarily give better results when scattered directly on the ground and plowed or harrowed in. It is advised only where coarse materials need to be put in better condition. It is also advisable for truckers and gardeners.

By the compost heap the farmer is able to multiply his available manure manyfold. He should remember that anything of vegetable or animal origin is a valuable fertilizer if put in proper condition. The compost heap is one means of doing this. One ton of leaves contains 15 pounds of nitrogen, 3.2 pounds of phosphoric acid, and 6 pounds of potash.

Locate the compost heap in an old shed, or build a shed, with any kind of cheap material for a roof. Spread on the ground a layer of stable manure 8 by 10 feet, 6 inches deep. Over this spread 100 pounds of acid phosphate or ground phosphate rock. The phosphate rock answers as well as the acid phosphate and costs about half as much. Continue these alternate layers until the manure is used up or until the pile has become inconveniently high. To these layers might be added straw, leaves, mold, or other litter, adding 100 pounds ground phosphate rock to each ton of material used. Be sure to wet all thoroughly. When the compost heap is completed, cover it about 4 inches deep with good loam or with forest mold.

When applying 2 tons per acre or less, the best results can be obtained by putting the compost in the furrow and bedding out on it. Be careful not to bury too deep, especially on clay soils. When using more than 2 tons per acre it is better to scatter broadcast.

Bearing in mind the supplemental value of the cowpea, it is safe to say that by using compost at least 50 per cent can be added to the productiveness of the average 100-acre farm, and that simply at the cost of a few tons of acid phosphate and a little labor. With the barnyard manure and with the cowpea at his service to save and gather nitrogen for him, the average farmer is simply wasting his money when he continues to buy nitrogen in commercial fertilizer when he could easily produce all that his land needs upon his farm. In some States cotton seed is used in addition to the acid phosphates. The seed should be made thoroughly wet before applying to the compost.

When Manure Should Be Applied.—It is the prevailing opinion of chemists as well as practical men that where it is practicable it is best to apply manure and urine to the soil in the freshest possible condition. The fertilizing constituents of well-rotted manure, as already explained, are more quickly available to plants, and the manure itself is less bulky and easier to distribute. On the other hand, fresh manure mixed with the soil readily undergoes a fermentation which not only increases the availability of its own fertilizing constituents, but also assists in rendering soluble the hitherto insoluble fertilizing constituents of the soil. In fact, even with special precautions to prevent injurious fermentation under the feet of the animals and in the heap, the greatest return is likely to be gotten from manure applied in the fresh condition.

The form in which manure should be applied (whether fresh or rotted) is determined largely by the soil on which it is to be used. If improvement of the mechanical condition is the main object sought, the best results will be obtained by applying the fresh manure to the heavy clay soils and the well-rotted manure to the light soils. If, however, the prompt action of the fertilizing constituents of the manure is desired, light soils, in a favorable season, are likely to utilize coarse manure to better advantage than heavy soils. Decomposition takes place slowly in heavy soils and the constituents of the fresh manure become available very slowly. In light soils, on the other hand, unless the season is dry, the conditions are such that the manure decomposes readily, and the fertilizing constituents are probably rendered available as fast as the plant needs them. There is also considerable danger on this class of soils that some of the soluble constituents will be carried away in the drainage if well-rotted manure is applied. For this reason such manure should be applied to light soils shortly before it is likely to be needed by the crop. In general, it may be said that for spring application the more readily available rotted manure is preferable to the fresh unrotted material.

On clay soils it often happens that manure produces no effect whatever during the first year on account of slowness of decomposition, but since the clay possesses very powerful absorption properties the manure is not lost. The fertilizing constituents are retained in the soil and are finally utilized by the crop. There is therefore little or no danger on this account in applying manure to clay soils a long while in advance of the planting of the crop. During dry seasons the manure may produce little effect, but with a sufficient amount of moisture its action is likely to be considerable. The application to such soils of large quantities of manure improve their physical condition.

The behavior of calcareous soils toward manure is very variable, depending upon the compactness of the soil. In those which are sufficiently porous decomposition goes on with great rapidity, and the soluble fertilizing constituents formed may be partially carried away in the drainage water before they can be taken up by the plants. For this reason, as in case of light soils, the manure should be applied shortly before it is needed by the crop.

Many experiments, notably those made by the Michigan and Wisconsin stations in this country, have shown that barnyard manure is one of the most effective means of increasing the productiveness of swamp or muck soils. This is thought to be due largely to the increase of available nitrogen brought about by the application of the manure.

The climate also may have an important bearing on the subject. In a warm, damp climate it is a matter of comparative indifference whether the manure is fresh or well rotted when it is applied, since under these conditions decomposition in the soil will be sufficiently rapid. In a dry season, however, it is well known that excessive applications of undecomposed manure manifest a tendency to burn out the soil, and this tendency, as has just been stated, is more marked in light soils than in heavy. In cold climates, where the season is short and the conditions for rapid fermentation in the soil unfavorable, the use of fermented manure is preferable.

Fresh manure has a forcing effect and tends to produce stems and leaves at the expense of fruit and grain. It is therefore better for early garden truck, grasses, and forage plants than for cereals or fruits.

Direct application of fermenting manure, as is well known, seriously injures the quality of tobacco, sugar beets, and potatoes, although mangel-wurzels appear to profit by large applications. For these reasons it is advisable in the case of cereals, tobacco, potatoes, and sugar beets to use only well-rotted manure or to apply the manure to the previous crop, or, where land is to be planted in the spring, to apply in the fall and allow to decompose during the winter. Sir J. B. Lawes has pointed out, however, that wheat on light soil is benefited by direct application of manure and that it is only on heavy soils that it is best to apply it to the preceding crop.

Manifestly, the rankness of fresh dung and urine could be controlled and utilized by applying the manure in small quantities and supplementing it with artificial fertilizers of kinds appropriate to the crops that are to be grown.

What has been said above regarding the application of fresh manure applies especially to manure containing only small amounts of coarse undecomposed litter. It is not generally advisable to apply very coarse manure before the litter has become at least partially decomposed.

It appears, therefore, that no fixed rules regarding the condition in which manure should be used which will apply to all cases can be laid down. It is a matter which naturally must be left largely to the individual judgment of the farmer, based upon a careful study of the character of the soil and climate and the requirements of the crop to be grown.

RESULTS OF EXPERIMENTS.

The Maryland Experiment Station has conducted a series of experiments as to the effect of manure applied at different seasons of the year. The results of the experiments are shown in the following tables:

Comparison of Yields from Applications of Fresh and Rotted Manure (Yields Per Acre in Bushels).

Kind.	* Corn Bushels.	† Wheat Bushels.
Unmanured	38.1	16.1
Fresh Manure	70.7	19.7
Rotted Manure	65.1	19.1
Gain from fresh manure	32.6	3.6
Gain from rotted manure	27.6	3.0
Gain of fresh over rotted manure	5.0	0.6

* Average of 4 crops. † Average of 2 crops.

The yields of fodder and straw were in favor of the fresh manure, and were in about the same proportions as given for the grains. The observations on the growth of grass showed decidedly in favor of the fresh manure, and were even more marked than with the other crops. Since well-handled manure in decomposition loses a portion of all its constituents, but relatively more of woody matter than of nitrogen and mineral elements, rotted manure is relatively richer than fresh manure.

Results of Applying Manure at Different Seasons (Yields Per Acre).

When.	Fresh Manure.		Rotted Manure.	
	Corn* Bushels.	Wheat† Bushels.	Corn* Bushels.	Wheat† Bushels.
Summer (July 26)	82.8	20.0	71.6	22.0
Fall (November 27)	69.1	18.4	68.0	17.3
Winter (January 12)	58.2	17.9	....	....
Spring (March 15)	57.5	17.8	61.4	18.0

* Average of 4 crops. † Average of 2 crops.

The results as given in the above table show clearly in favor of getting the manure on the land as long in advance of the time the crop is to use it as possible. The results as a whole are in favor of the use of fresh manure, but when the applications were made in the spring the rotted manure gave slightly better yields. The manner of applying manure should probably be varied with the character of the soil and the crop; yet usually the same results would be expected, on the average corn, wheat and grass soil, from a given practice.

Showing Results of Applying Fresh and Rotted Manure Before and After Plowing (Yields Per Acre).

WHEN.	FRESH MANURE.				ROTTED MANURE.			
	Corn *		Wheat †		Corn *		Wheat †	
	Grain	Fodder	Grain	Straw	Grain	Fodder	Grain	Straw
	Bu.	Lbs.	Bu.	Lbs.	Bu.	Lbs.	Bu.	Lbs.
Before Plowing	87.2	6950	20.3	1080	82.3	6550	19.8	760
After Plowing	98.1	7500	22.3	1160	82.6	6450	20.7	960
Gain from using Manure as a Top Dressing	10.9	550	2.0	80	0.3	—100	0.9	200

* Average of 2 crops. † Average of 1 crop.

The above results are clearly in favor of applying the manure after plowing as a top dressing. They also show decidedly in favor of the use of fresh manure. The question arises in the minds of the farmers as to whether the loss in manure should not be prevented by plowing it down in the fall, instead of leaving it exposed on the surface all winter. In order to get some definite data on this point, tests were conducted. It must be remembered that the manure was applied but once in the rotation, and that to the first crop of corn, and that the effects on the wheat was only what remained after two crops of corn had already had access to the manure.

Showing Yields of Corn and Wheat from Plowing Manure Under in Fall and Spring (Yields Per Acre).

WHEN.	FALL PLOWING.		SPRING PLOWING	
	Corn Bushels.	Wheat Bushels.	Corn Bushels.	Wheat Bushels.
Manure applied in the Summer............	75.9	20.9	78.4	21.1
Manure applied in the Fall................	62.2	17.4	69.9	18.3
Manure applied in the Spring.............	....	....	57.5	17.8

The results given in the above table are slightly, but uniformly, in favor of allowing the manure to remain on top of the land during the winter, and plowing it down in the spring, rather than plowing it down in the fall. This is probably due to the conditions near the surface being more favorable to nitrification, and consequently more of the manure has become available for crops.

Farmers sometimes object to the spreading of manure in summer, in the belief that when manure is so spread the hot summer suns burn out its substance, as they express it, and make it comparatively valueless. An inspection of the table shows this belief to be unfounded. The manure spread on July gave better results than that spread in either fall or spring.

In the following experiment the manure was applied in the winter on sod land, and was plowed under at once. On one plot the land was plowed to the usual depth prevailing in that field, or seven inches deep, and the other plot was plowed but five inches deep. The effects of this treatment on the yields of corn and wheat are given in the following table:

Showing the Results of Plowing Manure Under Different Depths Upon Yields of Corn and Wheat (Yields Per Acre).

How handled.	Corn * bushels.	Wheat † bushels.
Manure plowed under 7 inches........................	57.9	18.1
Manure plowed under 5 inches........................	56.5	14.7
Gain from deep plowing	1.4	3.4

*Average of 4 crops. † Average of 2 crops.

While these results do not show a very great difference, yet they are in favor of the deeper plowing, and as they were uniformly so from year to year with every crop, it may be safely concluded that it is usually best to plow deep, and that it is not harmful to plow the manure under deep. These results would seem to indicate that the contention of some farmers that manure should not be put in every deep is unwarranted, and that putting it in deep would probably stimulate the development of rots, and get additional advantages therefrom.

Methods of Applying Manure.—In applying manure to the field three methods are pursued: (1) The manure is placed in larger or smaller heaps over the field and allowed to remain some time before being spread; (2) it is broadcasted and allowed to lie on the surface for some time, or plowed in immediately, and (3) it is applied in the hill or drill with the seed.

The first method is objectionable because it increases labor of handling and chances of loss by fermentation and leaching, while uniform distribution of the manure is not secured. The spots on which the heaps stand are strongly manured with the leachings of the manure, while the rest of the field receives the coarse parts of the manure largely deprived of its valuable constituents. Another disadvantage of this method is that proper fermentation is interfered with by the leaching out of the nitrogenous matter and the drying action of the wind. The practice of storing manure in large heaps in the field is subject to some extent to the same objections. If, however, the heap is not allowed to lie too long and is carefully covered with earth the loss may be greatly reduced.

Spreading the manure and allowing it to lie on the surface should be practiced only on level fields where there is no danger from surface washing. It has been claimed that when manure is spread broadcast and allowed to lie on the surface there may be a serious loss of ammonia into the air, but experiments have shown that, in case of properly prepared manure, loss from this cause must be very small. On a leachy soil there may be a loss of soluble constituents in the drainage if the manure is spread a long while before the crop is planted, but in ordinary practice the loss from this source is also likely to be insignificant. In this method of application the fertilizing constituents of the manure are uniformly distributed, the liquid portion being gradually and thoroughly incorporated with the soil particles. One serious disadvantage, however, of the method is that the manure before being plowed in is leached to a large extent of its soluble nitrogenous compounds, which, as we have already observed, are necessary for fermentation, and therefore, it does not so readily ferment in the soil, it is not advisable therefore, in the case of light or sandy soils, to follow this practice, but it is preferable to plow the manure in as soon as spread.

As to the depth to which it is advisable to plow the manure in, the general rule should be observed that it should not be so deep as to prevent the access of sufficient moisture and air to insure fermentation and nitrification and to permit of rapid washing down of nitrates to the drain. In very compact soils the depth should not exceed 4 inches. In light soils this depth may be considerably increased, although in such soils there is more danger of loss by drainage than with heavy clay soils.

Application in the hill or drill is useful where the supply of manure is limited and the full immediate effect is desired. For forcing truck crops this method is especially valuable. Well-rotted manure is best suited to this method of application. It has been claimed, however, that manure applied in this way sometimes injures the appearance of root crops, especially potatoes, by increasing the amount of scab.

The so-called parking system, or feeding animals on the land, is a method of application which has many advantages; but the distribution of the manure by this system is irregular and subject to the same objection as broadcasting.

The application of liquid manure has certain obvious advantages and is largely practiced, especially in Europe. Manure leachings is a quick-acting, forcing manure, and is especially valuable for grass. The expense of cisterns for collecting the leachings and the trouble of hauling and distributing, together with the care which must be exercised to prevent loss of nitrogen from the readily fermentable liquid when it stands for any length of time, render it doubtful, however, whether this method is practicable except for special purposes and under peculiar conditions.

Authorities.—N. J. E. S. B. 150; Univ. Wis. B. 180; Bu. Plt. Ind. B. 692; Colo. Ag. Col. B. 168; W. Va. E. S. B. 140; La. E. S. B. 31; Tex. E. S. B. 112; Md. E. S. Bs. 122, 128; N. H. E. S. B. 21; Fla. E. S. B. 20; F. Bs. 56, 192, 245; Tex. E. S. B. 138; Ky. Univ. B. 140; Mass. Ag. Col. B. 81; O. E. S. Bs. 134, 183, 184; R. I. Ag. Col. Bs. 142, 143; Penn. Col. Bs. 54, 63; F. B. 44; Univ. Miss. B. 34; Cornell Univ. B. 56; Univ. Wis. B. 174; F. B. 192; Colo. Ag. Col. B. 99.

NEED OF COMMERCIAL FERTILIZERS.

A careful study of the present condition of farming in the United States indicates, that as a rule the manure produced on the farm is not sufficient to maintain its fertility, and that the need for artificial supplies is real, though the amount required may be considerably reduced by careful management.

Effects of Grain Farming.—In the system of so-called "grain farming," which has obtained over large areas of this country for a long time, and is still practiced, the live stock is often limited to a number sufficient only to the needs of the farm for labor and food; the grain is sold, and the manure is made up chiefly of the natural wastes or unsalable material, such as straw, stalks, etc. The grain contains proportionately greater amounts of nitrogen and mineral constituents than these wastes; hence the practice continued for a long time results not only in a deficiency in the soil of organic substances containing nitrogen, but also in an exhaustion of the mineral substances. The original character of the soil and its treatment measure the rate of exhaustion. The less fertile soils of the East and South are rapidly depleted, while the rich prairies and river bottoms maintain their fertility for a longer period.

Effects of One-Crop Farming.—The continuous cotton and tobacco growing of the South and the wheat growing of the West are even more exhaustive, since here the demands upon the soil are not changed—year after year the same crop is grown and the same kind and proportion of constituents are required, while even slighter returns are made in the way of manure than in the system of farming just described. Under such conditions the decomposition of the organic matter in the soil is accompanied by proportionately greater losses of nitrogen. Moreover, the land is left bare for a large part of the year, and its fertility is thereby still further decreased. The crops become less abundant each year, not because the soil is entirely exhausted, but because it is so far exhausted of those constituents essential to the special crop grown that its production is no longer profitable.

Changed conditions of farming, which have an important bearing on this point, are: (1) Increased cost of labor and lower prices of many of the products of one-crop farming, and (2) an increasing demand for market-garden products and fruit. For example, in growing wheat, the labor of preparing the soil, of sowing, and of harvesting is practically the same whether the yield is 10 bushels per acre or 30 bushels, and the same is true of a number of other crops; hence in case of the larger yield the cost of labor per bushel is materially reduced. Meager crops of a relatively low value can not be produced profitably with high-priced labor. Soils of a high degree of fertility are required in order to produce large yields of these crops. The return to the soil of only the wastes of the farm leads sooner or later to a decreased fertility, however good the management may be; hence the need of supplies of plant food from sources outside the farm in order that maximum crops may be produced.

Market Gardening and Fruit Growing.—It has been demonstrated, in the case of market-garden crops, that even very fertile soils contain too little available food to insure a maximum production. This is especially true where rapidity of growth, earliness, and high quality of produce are important factors. The areas now necessarily devoted to these crops are so great that the amount of farm manures available is much too small; besides, the constituents contained in such manures, being in part but slowly available, are less useful than the more active forms contained in commercial fertilizing materials. Market-garden crops are in a sense artificial crops, and, as a rule, need artificial supplies of plant food.

Fruit culture, an industry of growing importance, is profitable, particularly on the poorer soils near the eastern markets, largely in proportion of the amounts of the mineral elements applied in excess of those contained in soils otherwise well adapted to the crops. A proper supply of food not only enables the trees to resist unfavorable conditions, but improves the quality of the fruit and prolongs the bearing period of the orchards and vineyards.

It will be thus seen that commercial fertilizers can be used most advantageously either in reenforcing farm manures in general, or in providing a generous supply of quickly available plant food in specialized, intensive farming. It should be the aim in applying such fertilizers to supplement rather than to replace entirely the manurial resources of the farm, for the best results from their application may be secured only on soils well stocked with organic matter (humus), a material that can be maintained in the soil only by the systematic application of the bulky barnyard or green manures.

The use of commercial fertilizers is necessary to maintain the fertility of farms upon which live stock is not kept. The use of these fertilizers is constantly increasing and their advantages for special crops; ease of handling; quick availability to plants, as well as freedom from weed seeds, are being appreciated.

WHAT THE FARMER SHOULD KNOW.

Commercial fertilizers are mainly valuable because they furnish the elements—nitrogen, phosphoric acid, and potash—which serve as food, not as stimulants. The kind of farming in the past and the demands for special products in the present make their use necessary in profitable farming. In order to use them profitably the farmer should know—

(*a*) That nitrogen, phosphoric acid, and potash are the essential manurial constituents.

(*b*) That the agricultural value of these constituents depends largely upon their chemical form.

(*c*) That these forms are contained in specific products of a well-defined character and composition, and may be purchased as such from dealers and manufacturers and may be mixed successfully on the farm.

In making up the manure for a crop, the farmer should be guided chiefly by two considerations. He must ascertain wherein the soil, upon which the crop is to be grown, is deficient, and he must know the requirements of the plant which is to live upon it. These matters are best ascertained by actual experiment, carried on by the farmer himself on his own land, using different fertilizing ingredients to show him what elements are lacking. We will suppose that the farmer has determined what he is going to use, and how much per acre, and will endeavor to explain how different fertilizing materials are to be combined and prepared.

There are two distinct cases. In the one case, the plant food of the materials to be used is already in sufficiently available form, and the different ingredients need only to be well mixed in the proper proportions. In the other case, some of the materials need to be changed before they are put in the soil, and must be composted, or rotted.

A rapid growth of foliage and a deep green color of the same give evidence of an ample supply of nitrogen in the soil; if the foliage seems watery and the growth of the plants is more or less rank, there is most likely a need of phosphoric acid, and probably of lime.

If the plants make a rather stunted growth, under conditions of normal supply of water, and mature early, there is too much phosphoric acid in the soil to go with the other essential fertilizing elements present, and nitrogen and perhaps potash will be apt to materially improve the crops grown. Potash fertilizers are, generally speaking, of special benefit in case of leafy plants, like tobacco, cabbages, beets, clover.

The user of commercial fertilizers should make such applications as he has found by experience to be best adapted to his soil and the crops which he is growing. Methods which he has found good should not be abandoned and new ones tried on a large scale until he has carefully tested the new methods and found them good. There is no doubt that many improvements can be made in the application of fertilizers. The progressive farmer will make tests of different fertilizing mixtures on his soil, even if these tests are confined to a comparsion of two different mixed fertilizers. Such experiments will prove profitable when properly conducted.

The suggestions already given lead to another of great importance, viz, that the use of fertilizers should be systematic. In order that this may be accomplished, a definite system of cropping should be adopted and a definite scheme of manuring worked out that shall meet the conditions of crop, season, and climate, and enable the farmer to utilize to the best advantage home and local supplies of manure. While it is impossible to give more than the merest outline of such methods, the following suggestions are offered:

In the first place, in nearly every State or even locality, some one system of cropping is better adapted to the conditions than another. It may be the extensive system, which includes large areas and such crops as grain, cotton, tobacco, or sugar cane; or the intensive system, with smaller areas and crops of quicker growth and higher value. For the former, a method of manuring should be adopted which is not too expensive, but which provides for increased crops and gradual gain in fertility. It would be impracticable in extensive farming, for example, to attempt to increase the yield of a wheat crop from 12 to 30 bushels per acre by the addition of fertilizers only; for, as already pointed out, plant food it but one of the conditions of fertility, and if it were practicable from the standpoint of yield, it would be folly from the standpoint of profit.

The variations in the needs of soils and crops make it desirable that every farmer should know his own particular requirements. Such information may be secured more easily than is commonly supposed by growing the same crop and under the same conditions with different fertilizers. The knowledge thus obtained could be made quite valuable for any given locality, and may serve an important purpose in indicating the most economical use of fertilizer materials. While such tests are not so difficult or expensive as is often supposed, it is recommended that before the farmer undertakes them for the first time he seeks the advice of some one familiar with the details of such work, or, better still, apply to the experiment station of his State.

It is important that the farmer should know whether it is the soil or the plant that needs the food. The food may be in the soil, but not in a condition that the plants can make use of it. In that case a fertilizer that will release the food and make it available is needed.

FERTILIZER REQUIREMENTS OF DIFFERENT SOILS AND CROPS.

Nitrogen, phosphoric acid, and potash are the constituents most likely to be deficient in soils or most quickly exhausted by the production and removal of crops. They are known as essential fertilizing constituents, and the value of a commercial fertilizer is determined most exclusively by the amount and form of the nitrogen, phosphoric acid, and potash which it contains. It does not follow, however, that all soils or crops will respond equally to applications of materials containing these elements, for the needs of soils and the requirements of crops vary.

Soils differ as to their needs for specific fertility elements, owing to their methods of formation or to their management and cropping. A sandy soil is usually deficient in all the essential plant-food constituents—nitrogen, phosphoric acid, and potash—while a clayey soil usually contains the mineral elements in abundance particularly potash. On the other hand, a soil very rich in vegetable matter is frequently deficient in mineral matter, while a limestone soil is likely to contain considerable proportions of phosphoric acid. These are the indications in a general way, and they explain why it is that different kinds of soil that have not been cropped differ as to their need of the different fertilizing constituents.

The soils of no two farms are alike—neither are the soils of two fields on the same farm exactly alike. The total plant-food in one field differs from that of the adjoining field; the amount of decaying organic matter (humus) differs in different fields; the degree of coarseness or fineness of the soil particles varies greatly; the moisture conditions of no two fields are identical; neither are other physical conditions, nor texture of the soil exactly alike in two different fields—and so on with an almost infinite number of conditions, each having more or less influence upon the fertility or productivity of the soil, each having its influence upon plant growth.

Every observing farmer is familiar with the fact that while he can raise from seventy-five to one hundred bushels of corn per acre upon one part of his farm, another part of the farm will produce only from fifteen to twenty-five bushels per acre. He is also painfully cognizant of the fact that it requires more labor to produce the less number of bushels than it does to produce the greater. There are many causes for these failures, such as too much, or too little moisture, compactness of the soil, and other physical conditions, which incapacitates the plant for taking its food, or rendering the plant food contained in the soil unavailable. It is not, by any means, an easy task to overcome these difficulties.

The results of experiments made at the various Experiment Stations bring out in a striking manner the fact that soils vary widely in their requirements. The results obtained in one locality may be inapplicable in another.

Certain soils are naturally deficient in plant food even when first placed in cultivation; they do not supply a sufficient quantity of some one essential plant food to produce good crops. A great many soils are naturally deficient in phosphoric acid. This is particularly true of sandy soils.

If the store of plant food in the soil is drawn upon by crops and the crops taken away, in time the fertility of even the richest soil will be depleted unless the plant food is restored. A great many soils which were originally very productive have lost their fertility in this way.

Changes are going on in the soil which convert materials containing nitrogen into nitrates and ammonia. These can be taken up by plants, while the original nitrogenous matter cannot, but nitrates are very soluble in water and may be washed out of the soil. Under clean cultivation a considerable loss of nitrogen has been known to occur in this way; sometimes as much as 60 pounds per acre. Such loss would, of course, tend to deplete the store of nitrogen in the soil.

Truck crops, which must grow rapidly and mature early, make very heavy demands upon the soil for plant food. Even fertile soils may not supply the necessary plant food with sufficient rapidity. With crops of this nature the application of commercial fertilizers is usually profitable.

Some soils are deficient in one element and some in another; and frequently a soil is found that is deficient in two elements, but no soil is found that is deficient in all of the three elements—nitrogen, phosphoric acid, and potash. Nitrogen is usually the most deficient element in soils that are said to be getting "thin."

Methods of management and cropping also exert an influence; for example, soils of equal natural fertility may not respond equally to uniform methods of fertilization, because in the one case a single crop, requiring for its growth proportionately more of one of the essential elements than of another, is grown year after year, and it may be that the element required is the one that exists in the soil in least quantity. On the other hand, crops may be grown that demand but minimum amounts of the element in question; hence its application to the soil for the one crop may be followed by largely increased returns, while for the other but little if any increase in crop is apparent.

In the matter of management, too, a considerable variation may be observed. One soil may lose a large portion of its essential constituents, because no pains are taken to retain for the use of the crop the plant food annually rendered available through the natural agencies of sun, air, and water; while in another, by means of careful cultivation and the use of absorbents and catch crops, the constituents made available are largely retained.

HOW TO DETERMINE THE REQUIREMENTS OF THE SOIL.

One of the most common inquiries is, how the fertilizer requirements of a soil may be determined. It is a very common and natural belief that the proper way to do this is by analyzing a sample of the soil in question. This method would doubtless be satisfactory if it were not for the fact that it is almost impossible to tell by analysis how much of the plant food present is available. The total amount of nitrogen, phosphorus, potassium and other plant food materials can be ascertained by analysis, but as far the greater part of this material cannot be secured by the plants, and the proportion that can be obtained varies decidedly in different soils, and with different crops, the determination of the total amount is of rather uncertain value in showing the fertilizer requirements of a soil.

The beneficial effect of any fertilizer on a particular soil depends on whether the fertilizer in question contains those elements of plant food in suitable quantity and quality in which the soil is deficient. In other words the supply of plant food in soils varies widely and every user of commercial fertilizers must select his fertilizer according to the conditions of his soil and the requirements of the crop which he wishes to raise. The question is often asked which is the best mixed fertilizer to use. The consumer can better answer this question for himself by a study of his soil conditions and crop requirements. A general statement may be made, however, to the effect that, all conditions being equal, the consumer should select those fertilizers which give the greatest amount of plant food in suitable and available forms for the least money.

The most satisfactory, and, indeed, usually the only method by which one can at present determine the needs of a soil is to ask the question of the soil itself by growing a crop upon it with different kinds of fertilizers and noting the result. Such soil tests with fertilizers have in many cases given results of much immediate practical value for the locality in which they were undertaken. As a rule, however, farmers have looked upon such experiments as something too costly and complicated for them to undertake and consequently they have perforce been content to use fertilizers in a more or less haphazard manner, and in many cases, no doubt, at a great financial disadvantage.

The best method of ascertaining what is needed in any given case to produce a particular crop is to put the question to the soil itself; and this method, though requiring care at all points, and caution in forming conclusions, is not in reality difficult. Such experiments should abundantly repay the investigator in the practical money value of the results.

Law of the Minimum.—Since so many conditions surround and influence the growth of a plant it is important to find out which ones affect the growth of the plant most. It has been found by experimentation that it is not the most favorable conditions but the most unfavorable ones which have the greatest influence upon the growth of a plant. There may be one hundred conditions favorable for plant growth, and five or even one, only, which is unfavorable. It is not the many favorable conditions but the few unfavorable ones which influence the growth of the plant, or crop.

If a field is unproductive on account of poor drainage or because of a lack of humus, it would not be made more productive by adding commercial fertilizer. On the other hand, if a field is unproductive, due to a lack of available plant-food, then the addition of fertilizers will increase its productivity. The essential conditions of a field which are the poorest or at the lowest ebb must be sought out and improved before the fertility of the field is increased. It happens many times that poor yields are not due at all to a lack of plant-food, but are due to essential conditions other than those of plant-food.

THE ELEMENTS NEEDED BY DIFFERENT SOILS.

Soils whose fertility has been greatly reduced through long-continued cropping and which respond readily to applications of stable manure, should receive a general fertilizer containing all three valuable fertilizer ingredients, nitrogen, phosphoric acid, and potash.

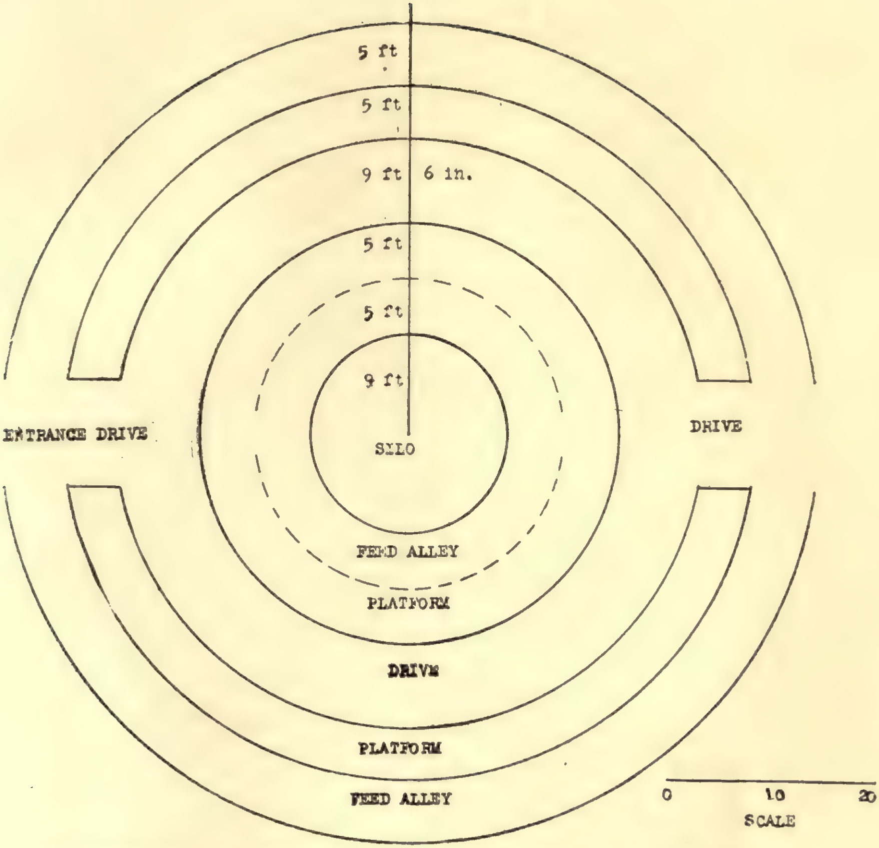
Sandy and light soils are especially benefited by applications of potash and will not, in general, be benefited by phosphoric-acid fertilization. The clay and loam soils, on the other hand, do not often need potash, but are apt to be improved by applications of phosphoric acid. Experiments have shown that acid soils (indicated by the litmus paper test) will respond to applications of lime (carbonate) and available phosphates.

Marshy soils, like all low-lying moist soils, are rich in organic matter and in nitrogen and require as a rule, potash and phosphoric acid, and sometimes lime. Potash or, still better, potash and phosphoric acid, have been found very effective in improving the productive capacity of black marshy soils.

It may be stated, as a general proposition, that soils of different types are likely to be especially benefited by the following special systems of fertilization:—sandy soils by nitrogen, prairie soils by phosphoric acid, peaty soils by potash and phosphoric acid, and all acid soils by carbonate of lime.

Phosphorus alone will not produce a maximum yield on lands that have been subjected for a long time to exhaustive cropping. Such lands must have nitrogen always, potassium often, and lime sometimes, before they will yield a full return. The need of lime may be determined by the growth of clover. So long as clover grows luxuriantly lime is not required, but when clover fails to grow on well manured land, dying out the second season and being replaced by sorrel, then lime should be added. Lime should always be preceded and followed by liberal fertilizing or manuring, for lime used alone, while it may stimulate the land to extra production for a year or two, will in the end produce greater exhaustion; but by alternating lime with manure and fertilizers the land will be kept in a healthy condition and will steadily increase in fertility. This is why limestone soils are celebrated for their productiveness.

Potassium is likely to be needed in soils which have been exhaustively cropped, especially if hay and straw have been sold from the land as well as grain. It is also sometimes the chief element needed on muck soils.



ARRANGEMENT OF COW STABLE IN BARN; TWO ROWS OF COWS TAILED TOGETHER. THE BARN IS CLEANED BY DRIVING AROUND BEHIND THE COWS. DEPT. OF AGR.
(See page 122.)

GYPSUM ROAD WINDING THROUGH SAND HILLS. DEPT. OF AGR.
(See pages 149-165.)

Nitrogen is invariably needed on hard-run lands, but it costs more, if purchased in fertilizers in quantity sufficient to meet the demands of the soils for full crop production, than phosphorus and potassium combined.

When fertilizers are applied to the soil, even though they contain much water-soluble plant-food, there is but little danger of loss by leaching from the soil. Soil with but few exceptions contain those elements which are necessary for the fixation of plant-food. Exceedingly sandy soils do not have the power of fixing or making insoluble the plant-food which is applied in fertilizers. Most soils, however, contain enough of those materials such as lime, iron, aluminum, zeolites and organic matter, which combine with the soluble plant-food applied in fertilizers and make it insoluble so that it does not leach from the soil. Even though it is rendered insoluble in water and hence leaches from the soil only in very small quantities, it is still available to the feeding rootlets of the growing crop.

Generally speaking, all forms of phosphoric acid and potash are fixed in the soil; nitrogen (with the exception of nitrates), which is contained in stable manure and other organic substances, and also nitrogen in the form of ammonia compounds is fixed in the soil.

The fixation of the potash and ammonia compounds is brought about by the so-called zeolites in the soil. The phosphoric acid compounds are fixed in the soil by compounds of lime, iron, aluminum and possibly magnesium. The exceptions to the above are, 1st, that all forms of soluble plant-food tend to leach out of very sandy soils. 2d, that nitrogen in the form of nitrate tends to leach out of all kinds of soils.

Soils differ in their requirements for plant food. Some respond to applications of phosphoric acid, others to nitrogen and others to potash. Sometimes a soil requires two or more kinds of plant food. The reason that soils differ in their requirements for plant food are as follows:

First. Soils are naturally different in their chemical composition, and their needs for plant food. As a rule, sandy soils are more likely to need potash than clay soils. They are also more likely to require nitrogen. The material of which clay soil is composed naturally contains more potash than the materials of sandy soils.

Second. Soils originally the same may become different through different treatment. One kind of crop may exhaust the soil of one kind of plant food and at the same time there is an abundance of the others. The cultivation of different crops in succession instead of the continuous culture of the same crop on the same soil, year after year, is more likely to utilize completely the plant food in the soil.

WHY DIFFERENT CROPS NEED DIFFERENT FERTILIZERS.

Crops differ in their requirements for plant food. Some require considerably more potash or nitrogen or phosphoric acid than others. They also differ in the ability which they possess to secure plant food. Some plants grow quickly and must take up their plant food rapidly.

They thus require an abundance of easily available plant food. Other plants grow more slowly and take a long time to mature. They can utilize the more difficultly available forms of plant food which would be almost useless to the plants first named. These differences account for the fact that different plants require different fertilizers even on the same soil.

It is not possible to prepare formulas for fertilizers which are best for this or that crop. This is seen by the fact that fertilizers put up for special crops by different manufacturers may vary widely in composition. The best fertilizer to use depends both on the soil and the kind of crop, though it is always safe to apply an abundance of plant food if the crop is valuable. However this may lead to waste of plant food. Some fertilizer formulas are based on the analyses of the plants, but plants vary in their power to secure food, as well as in their needs, and they take up an excess (especially of potash) when they can get it.

The legumes—a class of plant which includes the various clovers, peas, beans, vetches, etc.—differ from other plants in being able, under proper conditions, to acquire their nitrogen from the air through the aid of organisms working in their root tubercles, and can, therefore, make perfect growth without depending upon soil nitrogen. On the other hand, the various grasses and grains are not only dependent upon soil nitrogen, but they must have an abundance during their period of most rapid growth in order to attain their maximum development. For the latter class of plants favorable results are secured from the proper use of nitrogenous manures, while for the former class the application of nitrogenous manures simply results in supplying an element which could have been secured quite as well by the plant itself without expense. Illustrations could be multiplied, though they be less striking than this, showing that the variations in crops in respect to their power of acquiring food are really very great, and a right knowledge of this fact has a most important bearing upon the economical use of commercial manures.

Soils that will furnish nitrogen for large crops of corn and oats will also furnish some of the nitrogen for the clover crop, certainly as much as is left in the clover roots and stubble after both hay and seed crops are removed. Consequently if we are to enrich the soil in nitrogen by growing clover, the clover must be returned to the soil, either by plowing under directly or in the form of manure from pasturing or feeding.

In practical agriculture the fertility of the soil is of the first importance, for if the soil is so poor that satisfactory yields cannot be obtained then the difference between the cost of producing a crop and its market value may be so small that no adequate profit remains, while if a crop is sufficiently large then the cost of production tends to become relatively smaller, and the profits larger.

It is of course important to select crops adapted to the soil and climate and which have either directly or indirectly a high market value. It is important to select the right variety; to plant good seed in a well prepared seed bed and to give the crop thorough and intelligent cultivation, yet even if these things are all properly done and the soil is so poor that a small yield is obtained then there remains little or no profit to repay the husbandman for his efforts.

The fertility of the soil depends upon and is influenced by many complex factors. The physical condition of the soil; its water-holding capacity; the amount and availability of the different essential plant food materials; the presence or absence of injurious substances or organisms, each and all have their influence in affecting productivity and all are important. Plants cannot grow, however, unless they have food, and other things being equal the luxuriance of growth depends, not upon the total amount of available plant food present in the soil and atmosphere, but upon that particular food material which is present in the smallest amount relative to the needs of the crop. For example, if only enough potash in an acre of soil becomes available in one season for the production of one thousand pounds of hay per acre, then only one thousand pounds of hay per acre will be produced, even though there is present enough available phosphoric acid, lime, nitrogen, iron, sulphur, magnesia and silica for the production of five tons of hay per acre.

When commercial fertilizers are relied upon entirely to maintain a high degree of crop production a fertilizer containing all three constituents, nitrogen, potash, and phosphoric acid will give better results than a fertilizer containing only one or two of these constituents. Aside from the fact that a fertilizer should be especially rich in phosphoric acid experiments do not indicate the exact proportion in which nitrogen, potash and phosphoric acid should enter into a fertilizer for best results.

If leguminous crops are raised and either plowed under or fed on the farm and the resulting manure carefully saved and applied to the soil it is very probable that in practice it will be necessary to purchase only phosphoric acid in order to increase the productiveness of such soils and to maintain them in a condition of high fertility.

DO COMMERCIAL FERTILIZERS INJURE THE SOILS?

There are two ways, and possibly three, in which the use of the common commercial fertilizers injure the soil. First, they actually contain practically the full measure of the acidity represented by the sulfuric acid used in their manufacture. They do not contain sulfuric acid as such, nor any other free acid; but they do contain acid salts, which require just as much lime for their correction or neutralization as would the sulfuric acid itself. On the whole, however, this tendency to produce, or increase, acidity in the soil is a minor matter, because it can be corrected from time to time by the addition of ground limestone at small expense.

The second way in which the use of commercial fertilizers injures the soil is of much greater importance, although it is indirect. It is due to the fact that they are too expensive to permit their use in sufficient quantity to supply as much plant food as the crops remove; and the result is that where they are used they serve in part as soil stimulants.

To illustrate this: Suppose one applies 200 pounds to the acre of the average commercial fertilizer, and then harvests a crop of 60 bushels of corn. He will remove in the corn crop about twice as much phosphorus, ten times as much potassium, and twenty-five times as much nitrogen, as he applied in the fertilizer. The facts are that he has not only removed more plant food than was furnished in the fertilizer, but he has taken more from the soil itself than he could have taken without the fertilizer, because the quick acting fertilizer has stimulated the early growth of the plants and enlarged the root systems and thus enabled the crop to draw more heavily upon the soil. Besides this, the fertilizer contains manufactured landplaster, which is one of the most powerful soil stimulants. Suppose the farmer grows oats the next year without fertilizing, applies another 200 pounds per acre for the following wheat crop, and then with no further additions grows two crops of timothy and clover hay. He can thus wear his soil out more rapidly than he could without the stimulating action of the fertilizer. This would not be the case if he would apply more plant food than his crops remove.

There is a third way in which commercial fertilizers may possibly injure the soil. The value of steamed bone meal and of raw rock phosphate is due to the tricalcium phosphate which they contain. When these materials are treated with sulfuric acid, the insoluble, neutral tricalcium phosphate is converted into soluble, acid monocalcium phosphate; and, at the same time the sulfuric acid is converted into calcium sulfate, which is essentially the same compound as plaster of Paris, a well known material with strong cementing properties. It is a fact, that with the long continued use of acid phosphate, alone or in mixed fertilizers, the soil usually becomes harder and more compact. That is to say, it develops a bad physical condition. In large part, this is probably due to the destruction of humus or organic matter, but to some extent it is very possibly due to this manufactured cementing material.

There are, indeed, cases in which, apparently, the fertilizer has been injurious. A farmer, for example, finds that the application of 200 pounds per acre of acid phosphate will increase his crop considerably. He makes this application for three or four years, then finds that his crop is smaller than it was to start with, or he discontinues the application of fertilizers and does not get much of a crop. Apparently, the acid phosphate had injured the soil.

The injury has been caused by the method of farming and not by the fertilizer. The acid phosphate supplied only phosphoric acid to the soil. The increased crop increased the demand for nitrogen and potash so that the quantity in the soil has diminished until it is no longer the phosphoric acid but the nitrogen or potash which controls the yield of the crop. The one-sided application of plant food has aided in the exhaustion of the soil in the other plant food. The other plant foods can, of course, be restored by using fertilizers containing them.

Muriate of potash is extensively used as a source of potash in fertilizers. It is a very concentrated fertilizer, each 100 pounds of it containing about 50 pounds of actual potash. The potash in this form is, as a rule, somewhat cheaper than in the form of sulphate of potash. If, therefore, it is as effective as the sulphate and does no injury to soil or crop it is advisable to use it in preference to sulphate. It has been found, however, that although the muriate of potash is, as a rule, a very valuable fertilizer the chlorin with which the potash is combined in it may injuriously affect the quality of certain crops, such as potatoes, tobacco, etc.; and Professor Goessmann, of the Massachusetts station, has observed that if the muriate is used without proper precautions on soils with a limited supply of lime that full benefit of the potash which it supplies may not be obtained because the lime of the soil is converted into a soluble form which is either washed out in the drainage or accumulates in the upper soil and poisons the plants. He observed that oats, rye, and soja beans grown on soil which had received applications of muriate of potash for a number of years in succession continued to decrease in yield and were unhealthy in appearance, and it was suspected that this condition was due to the action of the muriate of potash on the lime of the soil.

When common salt (sodium chlorid) and muriate of potash (potassium chlorid), which are readily soluble, are brought in contact under favorable conditions with the insoluble carbonate of lime, the form in which lime chiefly occurs in the soil, a chemical change takes place by which the lime is converted into a form (chlorid) soluble in water and poisonous to plants. An examination of the drainage water of the soil showed the presence of considerable amounts of the soluble lime compound (chlorid) in the soil fertilized with muriate of potash (much greater than where sulphate had been applied), and thus confirmed the opinion that some such chemical change as the above had actually taken place in the soil. The valuable potash had passed into more insoluble forms and was thus protected from leaching—a very desirable result—but this was accomplished at the expense of the lime. If lime is abundant in the soil and drainage good no immediate harm is likely to result from such a change in a favorable season, but if the supply of lime is limited, serious results may follow the continued use of muriate of potash unaccompanied by applications of lime. The conclusion that the unhealthy appearance and decrease in yield of the crops were due to loss of lime from the soil was confirmed by the fact that when 500 to 600 pounds per acre of lime was applied broadcast early in the spring, and subsequently plowed under before preparing the soil for manuring and seeding, the succeeding crops of oats looked healthy from the beginning to the end of the season.

On account of the poisonous properties of the lime compounds formed, muriate of potash is a safer fertilizer on a deep soil with open subsoil than upon a shallow soil with a compact clayish subsoil, because in the former the injurious lime compounds formed pass readily out of the reach of plants, while in the latter they tend, as already suggested, to accumulate in the surface soil, where they may work great injury to the plant.

These objections to muriate of potash do not apply to the sulphate. Therefore, if the two forms are equally available it would be advisable in case of soils containing a limited supply of lime to use the sulphate instead of the muriate. If the muriate of potash is used liberally it should be accompanied by periodical applications of lime.

AGRICULTURAL VERSUS COMMERCIAL VALUE OF FERTILIZERS.

The agricultural value of any of the fertilizer constituents is measured by the value of the crop increase which its use may be expected to produce. Knowing the average composition of wheat, we may easily calculate the agricultural value of any given quantity of plant food as tending to produce, under suitable conditions, a certain increase in the yield of grain. The agricultural value of plant food is not a fixed quantity. It is a variable factor, depending upon the availability of the constituent or constituents, as well as depending upon the value of the crop produced. The availability of any constituent is, in turn, dependent on its origin, on its treatment, and on the conditions of soil and climate under which it is applied, while the value of the crop produced is affected by its character, by the distance from the point of consumption, and by the conditions of demand and supply. It is quite evident, for instance, that the agricultural value of a pound of soluble phosphoric acid is likely to be greater than that of a pound of insoluble phosphoric acid, when applied under the same conditions of soil and crop, since in the one case the constituent is in its most available form, while in the other it is but slightly available. Furthermore, the soluble phosphoric acid in question may exert its full effect and lead to a large increase in the yield of certain crops without leading at the same time to increased profits. In other words, the increase produced by the application of the fertilizer may possess a value smaller than the cost of the latter. On the other hand the same fertilizer when used in connection with a crop possessing a greater market value may prove highly profitable, since the monetary return secured from the crop increase is much greater than the cost of the fertilizer. Hence it should be remembered that slowly available materials can not be expected to give profitable returns, particularly upon crops with a short growing season, and that expensive materials can not yield returns that are as remunerative with crops of relatively low value as they are with crops of relatively high value.

The agricultural value should not be confused with what is termed commercial value or cost in market. The latter is determined by market and trade conditions, as the cost of the crude materials, the methods of their subsequent treatment, etc. Since there is no strict relation between agricultural and commercial value, it frequently happens that a constituent in its most available form, and possessing under suitable conditions a high agricultural value, costs less in the market than the same constituent in forms less available and possessing a slighter agricultural value. It is clear, therefore, that the commercial value, that is, the cost of any fertilizer constituent, need not necessarily bear a direct relation to its agricultural value, that is, the power of producing a certain crop increase.

The agricultural value of a fertilizer is measured by the benefits received from its use, and depends upon its fertilizing effect, or crop-producing power. As a broad, general rule, it is true that ground bone, superphosphates, fish scraps, dried blood, potash salts, etc., have a high agricultural value which is related to their trade-value, and to a degree determines the latter value. But the rule has many exceptions, and in particular instances the trade-value cannot always be expected to fix or even to indicate the agricultural value. Fertilizing effect depends largely upon soil, crop and weather, and as these vary from place to place and from year to year, it cannot be foretold or estimated, except by the results of past experience, and then only in a general and probable manner.

The different phosphates used in fertilizers differ widely in availability, i. e., in the readiness with which they are taken up by plants, and different plants have been found to vary greatly in their capacity to assimilate the phosphoric acid of a given phosphate. The insoluble phosphates are much cheaper than the soluble forms. Phosphoric acid in soluble form costs in the market from 4 to 6 cents per pound (often more in mixed fertilizers), while that of the crude mineral phosphates is worth less than 2 cents per pound. If, therefore, it can be shown that certain plants can utilize some of the insoluble phosphates to good advantage the outlay for phosphates may be greatly reduced.

The agricultural value and the commercial value of fertilizing materials are not synonymous terms. The agricultural value of a fertilizer is determined by the increase and quality produced by it in the crop. The commercial value of a fertilizer is determined by the cost of the materials which enter into its composition. A fertilizing material of high commercial value may have a low agricultural value on a particular soil or crop. On another soil or crop the same material may have a high agricultural value.

WHAT ARE COMMERCIAL FERTILIZERS?

In connection with the subject of fertilization the terms manures, fertilizers, commercial fertilizers, chemical fertilizers, indirect fertilizers, natural fertilizers, artificial fertilizers, superphosphate, complete and incomplete manures, etc., are used, and there is often a misunderstanding of the meaning of some of these. A fertilizer is any substance which furnishes deficient plant food in an available form. Fertilizers are either natural or artificial; the former including manures, or the solid and liquid excrement of animals and green crops plowed in to increase fertility.

The latter, (artificial fertilizers) including commercial fertilizers, sometimes called prepared fertilizers, and chemical fertilizers, or those mixed from crude fertilizing chemicals.

A fertilizer is complete, sometimes called general, when it contains nitrogen, phosphoric acid and potash, and incomplete, sometimes called special, when furnishing only one or two of these deficient forms of plant food. Mixed animal manures are all complete, or general, fertilizers. Green crops plowed under are complete. The artificial fertilizers, whether commercial or chemical, are complete or incomplete, according as they are mixed from raw materials containing the three forms of plant food, or as they lack one or more of these. A fertilizer is said to be indirect when it does not contain deficient plant food, but in some way acts on the soil so as to hasten the change of unavailable plant food in the soil into available, that is, they increase the natural capacity of the soil. Lime, gympsum, salt, etc., so far as they have any action, belong to this class; others, like ashes, and especially leached ashes, are both direct (furnishing plant food) and indirect.

Land-plaster, gypsum or calcium sulphate, are different names for the same compound. Gypsum or land-plaster is nothing more than the sulphate of lime rock which has been ground exceedingly fine. When limestone is burned the resulting product is calcium oxide or quicklime, sometimes called stone-lime. When exposed to the air it becomes air-slaked and is then calcium carbonate or carbonate of lime.

The so-called complete fertilizers are commonly made by mixing two tons of acid phosphate with two tons of filler containing small amounts of nitrogen and potassium. The most popular filler is the decayed peat from bogs.

The terms high grade and low grade as applied to fertilizers are neither absolute nor very well defined. It is customary to speak of those fertilizers containing a relatively large amount of plant food per ton as high grade, and those with a relatively small amount as low grade. Another distinction is made on the basis of the kind and quality of the materials of which the fertilizer is made up. If the high grade standard materials like nitrate of soda, ground bone, acid phosphate and muriate of sulphate of potash are used exclusively in its making the fertilizer is said to be high grade, while if the cheaper, inferior and less soluble materials like garbage tankage, wood ashes and kainit are used, the fertilizer is called low grade. Sometimes any complete fertilizer containing less than 2 per cent of nitrogen is called low grade. As regards price it may be said that complete fertilizers which retail for $30 per ton or less are low grade; those retailing from $30 to $38 are medium grade, and those selling for more than $38 are high grade.

Whether it is more economical to buy a high grade or a low-grade fertilizer is an important question, but unfortunately it is one not difficult to answer. All fertilizers should be bought on the basis of the amount of available plant food they contain. A ton of high-grade goods will contain a larger amount of plant food than will a ton of low grade, but because the price of the latter is low and therefore attractive, and because to many people a fertilizer is a fertilizer, regardless of its composition, many tons of these low-grade goods are sold annually.

Concentrated high grade materials necessarily command a higher price, but the difference is not always proportional to the difference in actual plant food, the high grade materials as a rule being cheaper, pound for pound of actual plant food.

FERTILIZING MATERIALS.

The term form, as applied to a fertilizing constituent, has reference to its combination or association with other constituents, which may be useful, though not necessarily so. The form of the constituents, too, has an important bearing upon its availability, and hence upon its usefulness as plant food. Many materials containing the essential elements are practically worthless as sources of plant food, because the form is not right; the plants are unable to make use of them—they are unavailable. In many cases the form of these materials is changed by proper treatment and they become valuable, not because the element itself is changed, but because it then exists in such form as readily to feed the plant.

Commercial mixed fertilizers are prepared by mixing together acid phosphate, nitrogenous materials, and potash salts in the proportion necessary for the composition desired. In some fertilizers the phosphoric acid comes partly from bone or tankage. These fertilizers contain only a small proportion of their available phosphoric acid in the water-soluble form and they contain a considerable quantity of insoluble phosphoric acid. Fertilizers made with acid phosphate alone contain two-thirds or more of their phosphoric acid in the water-soluble form and only about one-sixth of the total quantity present is insoluble. Acid phosphate is considered as a more desirable source of phosphoric acid in mixed fertilizers than bones or tankage.

After the proper materials have been weighed out, they are mixed thoroughly and passed through a coarse sieve to insure a uniform degree of fineness. Any other material which does not pass through the sieve is ground up and added to the mixture. Sometimes the ingredients must be ground up before they can be mixed, as they may have become hard and lumpy.

A large number of different substances containing the fertilizer elements necessary for the growth of crops are found stored in nature, in rocks, soils, or deposits of various kinds. Refuse-products in several important manufacturing industries furthermore furnish one or more of these elements. These substances are placed on the market and sold under the general name of commercial fertilizers. They may be of mineral, vegetable, or animal origin, and supply nitrogen, phosphoric acid, or potash, or mixtures of these ingredients.

Substances of this kind have been applied to cultivated soils from time immemorial, and experience has taught farmers that the results secured by applying them may fully equal and even excel those realized from the use of barn yard manure. A number of the commercial fertilizers are easily soluble in water, and, as a result, quick-acting, while others have to go through a process of decomposition in the soil before they can be of much benefit to crops.

Grade of Materials.—Materials that do not show a wide variation in composition, and in which the constituents are practically uniform in their action, may be regarded as standard in the sense that they can be depended upon to furnish practically the same amount and form of the constituents wherever secured. For example, a ton of nitrate of soda or boneblack superphosphate (dissolved boneblack) will on the average furnish 320 pounds of nitrogen or of phosphoric acid, the nitrogen all in the form of a nitrate and the phosphoric acid, practically all soluble. Hence nitrate of soda, sulphate of ammonia, dried blood, and superphosphates and potash salts are standard products, because they can be depended upon, both in respect to the content and form of their constituents.

On the other hand, the low-grade or nonstandard materials are not merely poorer in their total content of plant-food constituents, but also contain forms of the latter which are very variable in their availability. No exact value can be assigned, for instance, to ground bone, since this is a product quite variable in composition and in the availability of its nitrogen and phosphoric acid, owing to its origin, its mechanical condition, and the method of treatment to which it was subjected. Because of the differences thus introduced different samples of bone cannot be expected to yield the same results, even though they be used under the same conditions of soil and climate. The same applies even more strongly to the various kinds of tankage. We note here wide differences in the proportion of nitrogen and of phosphoric acid, and differences as great or greater in the availability of these constituents. They can not be expected, therefore, to yield constant and uniform results under any given climatic conditions in the same degree characteristic of the standard high-grade products.

Mixed Fertilizers.—The tendency of the fertilizer trade in this country has been toward the manufacture and sale of mixed fertilizers containing moderate quantities of two or three of the essential fertilizer ingredients. The various brands of fertilizers thus compounded are sold under special names indicating the purpose for which the fertilizer is supposed to be especially adapted. The names sometimes also give a clue to the origin of the fertilizer, but oftener do not. Ammoniated superphosphates manufactured and sold by eastern fertilizer manufacturers, are prepared from acid phosphates (dissolved bone, superphosphate) to which some nitrogenous fertilizer material has been added. As it is difficult to prove the origin of organic nitrogen compounds by chemical tests, it is but natural that unscrupulous manufacturers should seize this opportunity to adulterate superphosphates with nitrogenous compounds of inferior fertilizer value, like leather scraps, horn shavings, hoof meal, etc.

When the farmer studies the apparent needs of his land and understands the subject of fertilization of crops he will prefer to buy special fertilizing materials of definite, known composition, in proportions best adapted for his purposes, rather than use mixed fertilizers, the different components of which he does not know, and parts of which may be of no particular value. The mixed fertilizers came into existence in response to a demand for this kind of goods, but it is believed that as farmers learn the principles governing the use of fertilizers and become familiar with the specific requirements of their soils and crops, they will less frequently call for general compound fertilizers and will buy the raw materials of known origin and properties which are required for their special purpose.

Nature and Causes of Variations.—All manufactured products or brands of fertilizers are made up of a mixture of the various kinds and forms of fertilizing materials and the differences that exist in the brands of different manufacturers are due both to differences in the character and to variations in the proportions of the materials used to form the different brands; that is, while all manufacturers must go to the sources of supply indicated, they may select either good or poor products and may vary the proportions of the different materials used.

The difference between a good brand of fertilizer and a poor one lies not so much in differences that may exist in the total amount of plant food contained as in the quality of the materials of which the two are made. For instance, in one brand the nitrogen may have been derived entirely from insoluble organic materials and the phosphoric acid from untreated phosphates rather than superphosphates; while in another the nitrogen may have been derived from the three sources of nitrogen, viz, nitrates, ammonia salts, and organic matter, and the phosphoric acid entirely from superphosphates. The total plant food contained in the first brand may be quite as great as it is in the other, yet the immediate results obtained from its use would be less satisfactory than those obtained from the one containing the more active forms of fertilizing constituents.

A fertilizer containing foreign substances, of themselves worthless as a source of plant food, is not necessarily adulterated. It may contain the full quantity of the fertilizer ingredients guaranteed, and the foreign substance in question may act only as a filler. On the other hand, a fertilizer may contain one or more of the plant food constituents in forms so inert, and so difficultly available, as to make them practically worthless as a source of the constituents in question. This would apply, for instance, to peat, which in a finely ground state is known to have been used as a source of nitrogen in mixed fertilizers. Because of its resistance to the agencies of decay, it possesses scarcely any value as a source of nitrogen, and hence its use under such conditions could justly be designated as adulteration.

What Chemical Analyses Show.—The differences that exist between good and poor fertilizers are quite clearly shown by the chemical analyses made by the various experiment stations, provided the analysis is carried far enough to show both the amount and form of the nitrogen, phosphoric acid, and potash. For instance, an analysis which shows that a considerable proportion of the nitrogen exists as nitrates or as ammonia is positive evidence that good nitrogenous materials have been used; if it shows that the phosphoric acid is largely in a soluble form, the consumer knows that superphosphates have been used. On the other hand, if all the nitrogen is shown to be in the form of organic matter, and a large proportion of the phosphoric acid is found to be insoluble, it is evident that materials containing less active forms of plant food were used in the preparation of that fertilizer. In the next place, it is the quality and amount of plant food contained in a fertilizer which determines its value, rather that the relative proportions of the various constituents, though under certain well known conditions the latter is of very considerable importance. Special crop brands are particularly useful only when the soil is already in a good state of fertility and not deficient in any plant-food constituent.

With a more or less complete knowledge of the need of artificial supplies of fertilizer, the character, composition, and usefulness of the various materials, and the best method of purchase, the practical question arises, viz.: Will it pay to use them?

PRINCIPLES GOVERNING PROFITABLE USE.

Many of our most successful farmers are, by their practice, answering this question in the affirmative. It is, however, not entirely a question of plant food with them, and one phase of it may be illustrated by the following typical case: Mr. A applies fertilizer; his crop is largely increased, and a reasonable profit is secured. Mr. B applies the same amount and kind under similar conditions of soil, and receives no benefit. The difference in results is due, not to the fertilizer, but to the farmer himself. In one case the natural agencies (sun, air, and water) were assisted and enabled to do their maximum work, because care was taken to make the conditions other than the supply of plant food as perfect as possible, while in the other they were prevented from exercising their full influence, because physical conditions of soil were imperfect, on account of careless plowing, seeding, cultivation, and cropping.

The production of a large crop—that is, the transformation of large amounts of plant food into plant substance—presupposes not only an abundance of all of the ingredients, but the absence of unfavorable influences, such as excessive moisture, low temperature, improper aeration, acidity, etc. In other words, the profit from the use of fertilizers is measured to a large degree by the perfection of soil conditions which are entirely within the power of the farmer to control. The production possible from a definite amount of plant food can be secured only when the conditions are such as to permit its proper solution, distribution, and retention in the soil.

It has been demonstrated that it is entirely practicable and profitable under certain conditions to use as much as 1,000 to 1,200 pounds of high-grade commercial fertilizers for top dressing grass lands. The successful practice in this case is, among other things, dependent upon the absence of too great a degree of acidity in the soil and the presence of a good stand of timothy and redtop; in other words, of a sufficient number of vigorous plants to utilize to the best advantage the food offered to them. It has also been demonstrated that the best returns from the use of fertilizers may be secured when proper attention is paid not only to the varying needs of the different crops but also to the varying needs of the different soils. Applications of fertilizer ingredients suitable both in amount and proportion for one soil may be ill advised and wasteful on another soil. It is therefore necessary in the rational use of fertilizers to study the needs of the crop as well as of the soil. On certain soils and under certain conditions of crop rotation it may be advisable to provide for a better circulation of soil fertility by the use of the more slowly available, and therefore cheaper, forms of nitrogen and of phosphoric acid. Thus, there may be conditions, as already indicated, where finely ground phosphate rock, when used on soils well supplied with rapidly decomposing organic matter, may serve as a more economical source of phosphorus than superphosphate.

The fact that fertilizers may now be easily secured and are easily applied has encouraged careless use rather than a thoughtful expenditure of perhaps an equivalent amount of money or energy in the proper preparation of the soil for them. Of course it does not follow that no returns are secured from plant food applied under unfavorable conditions, but it needs to be emphasized that full returns can not be obtained under such circumstances, either with or without fertilizers.

It should be the aim in the use of commercial fertilizers to supplement the plant food derived from the soil itself in such a manner as to make possible the most profitable returns. The farmer should be in a position to decide whether the increase produced by the application of any given fertilizer is sufficient to pay for the extra expenditure of labor and money. He will be in a better condition to decide correctly by remembering that the relation of the cost of the fertilizer to the value of the increased crop is a variable factor, depending, aside from the climatic conditions, upon the availability of the constituents, the character and composition of the crop, and upon the market value of the latter. It may happen, for instance, that the liberal application of certain nitrogenous materials to crops of a low market value may result in a maximum yield of plant substance, and yet fail to return a profit simply because the cost of the nitrogen applied is so great as to exceed the value of the increase secured by its application. On the other hand, a similar application of the same material to a crop possessing a high commercial value may, without being as thoroughly utilized or without producing an increase proportionately as large, lead to much greater profits, mainly because the cost of the nitrogen, however considerable, is relatively small when compared with the money value of the crop increase secured from its use.

To make heavy application of fertilizer is costly. The increase in the yield of crops from the use of heavy applications of fertilizer on soils deficient in humus does not always correspond to the increase in the quantity of fertilizer applied. By increasing the humus content of the soil the yield or crops will be nearer in direct proportion to the quantity of fertilizer applied. Because of the frequent failure to observe this fact there is often a great deal of waste in the present method of using fertilizers. To prevent this waste the farmer needs to know more about the fertilizer constituents in fertilizers and the factors which influence their use.

APPLICATION OF FERTILIZERS.

Crops may be divided into two classes with reference to the application of fertilizers. The first class includes those crops which have a comparatively low value per acre and to which large applications of fertilizer cannot be made without costing a considerable proportion of the value of the crop. For these crops the plant food in the soil must be utilized as fully as possible and the application of fertilizer must be made as skillfully as possible. The cropping system should be arranged so as to utilize economically the residues from the previous application.

As a general rule, it may be said that it is not profitable to purchase all the nitrogen needed by crops of this character. The fertility of the soil must be maintained with nitrogen secured from the air, and nitrogenous fertilizers should be used only to supplement the supply secured in this way. This involves a rotation of crops, in which nitrogen-gathering plants are grown—cowpeas, vetch, bur clover, peanuts, etc.

The second class of crops includes those which have a high value per acre and for which even large applications of fertilizers may cost only a comparatively small proportion of the value of the crop. These crops, as a general rule, must be grown as rapidly as possible, and they require abundant supplies of plant food. Although attention should be paid to the needs of the soil, it is possible to make such heavy applications of plant food that the supply in the soil may be more or less disregarded. These crops can, of course, be followed by other crops to utilize the large residues of plant food.

It is not possible to make a strict classification of crops under these two groups, for conditions which place a crop in one group in one locality may place it in another group in another locality. A high price for a crop, due to market conditions, may change it from the first to the second group. Cotton, corn, rice, and alfalfa can be classed with crops of low acre value, and onions, sweet potatoes, tomatoes, melons, asparagus and similar crops with those of high acre value.

If fertilizers are used, the following general rule should govern: On rich lands use mainly fertilizers that will stimulate the fruit and not the stalk growth. On lighter lands use more of the elements to force growth, combined with others which will mature the fruit.

High-grade 14 per cent acid phosphate may be considered a basis for increasing fruit and hastening maturity of crops. Even on the richest land it has been demonstrated that a small percentage of nitrogen added to the acid phosphate gives better results. Use three parts of acid phosphate and one part of cotton-seed meal for cotton.

A mixture of one part of cotton-seed meal to two parts of high-grade acid phosphate will greatly increase the growing condition and will be better for medium soils. Air-slaked lime is of value for use on stiff or gummy soils to loosen them up, permit the air to enter, and prevent a sour condition of such soils when too wet. On thin or impoverished soils equal quantities of cotton-seed meal and acid phosphate can be used to advantage. In case the foregoing can not be obtained, standard-grade commercial fertilizers may be used. These should contain in the mixture 8 to 10 per cent of available phosphoric acid, 2 to 3 per cent of nitrogen, and 1½ to 2 per cent of potash, or on some lands a high-grade acid phosphate, 14 per cent, may be used. On black waxy land the best practice is to have the cotton follow a crop of cowpeas.

The question as to how fertilizers should be applied is somewhat difficult to answer because it depends on a number of conditions, especially the kind of fertilizer and the amount to be used. Phosphoric acid and potash, even in water soluble forms do not leach out of the soil to any appreciable extent. On the contrary, they do not distribute themselves well enough, and therefore should be applied to some depth. Nitrogen, on the other hand, finally leaches out of the soil unless taken up by the roots of plants. In some materials, however, it is much less readily soluble than in others. Tankage, for example, should be applied deep, and it is well to mix cotton-seed meal and blood with the soil; but nitrate of soda and ammonium sulphate should nearly always be applied as surface dressings. Only one application is advised for ammonium sulphate, but when large quantities, over 200 pounds to the acre, of nitrate are to be used, two applications of 100 pounds each are often made to advantage, one when the plants are first coming up and the other two or three weeks later. Potash salts when used in quantity, 100 pounds or more to the acre, are well applied in the fall, so that the winter rains may take out the chlorine, which when combined with either lime or magnesia acts in a detrimental manner to plant growth. Lime is also well applied in the fall. Acid phosphate when used as a top dressing may be applied either in the fall or in the early spring. When a small amount of fertilizer is to be used it is best applied as the seed is sown or as the plants are set out, in the row or in the hill or, when practicable, drilled with crops which are drilled. As a general rule only a heavy application of a complete fertilizer, say 1,000 pounds or more to the acre, is recommended to be applied broadcast and worked into the soil for crops which are planted in rows.

The most profitable fertilizer to apply depends upon the character of the soil, and the kind of crops to be grown. The previous treatment to which the soil has been subjected is also of influence. There are such variations in soils that each user of fertilizers must, to a large extent, be guided by his own experience. Based on the fertilizer experiments which have been made, and knowledge of the composition and properties of soils, suggestions for the fertilizers to be applied to different crops in different localities may be made, and the application of fertilizers as suggested will prove profitable in many cases, if judgment is used. More profitable results, however, may be often produced with a somewhat different formula, and it is in this respect that the experience of the individual must be applied. The best results with fertilizers are obtained when thorough cultivation is given.

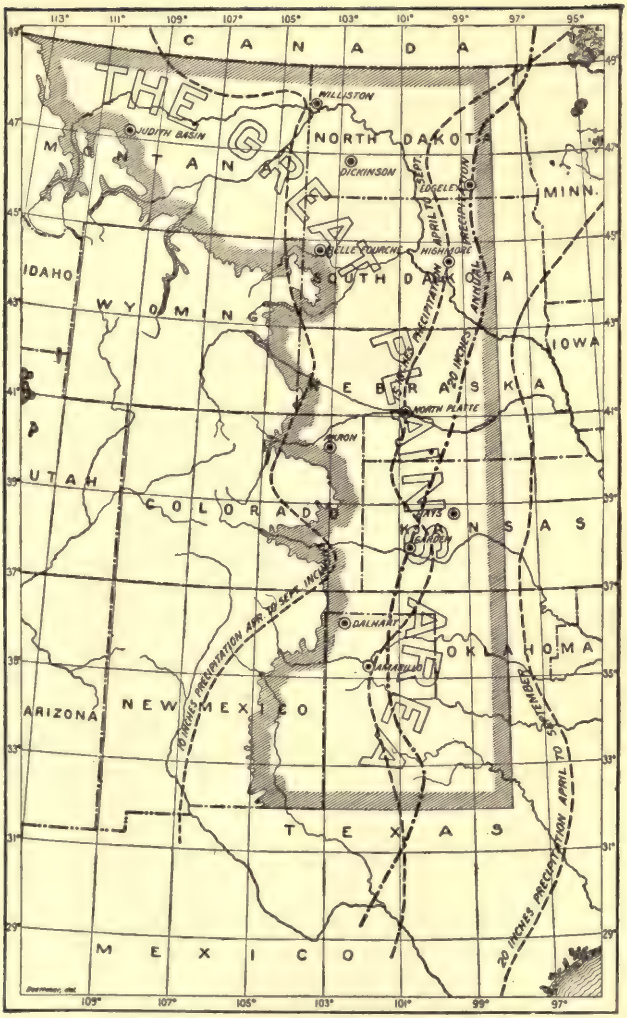
The user of fertilizer should distinguish between a large increase of crop and a profitable increase. With many crops it is possible to increase the crop by increasing the amount of fertilizer, but beyond a certain point, the increase in crop is no longer profitable. That is to say, the additional amount of crop secured does not pay for the additional quantity of fertilizer used. The point at which the addition of fertilizers ceases to be profitable depends upon the selling price of the crop. Crops of high selling price per acre will of course bear a profit in larger applications of fertilizer than low selling crops.

In raising crops, therefore, we need not be at the expense of supplying all of the deficient plant food contained in the crop we raise, but only the excess which the crop contains over and above that which the soil is capable of supplying, year in and year out, indefinitely. It must be remembered, however, that not all of the plant food supplied will be received by the crop. Thus only one-half (50 per cent) of the nitrogen applied in the fertilizer is recovered, the remainder is either lost in the drainage water, or is carried down into the subsoil or held in the soil. It has been demonstrated that very little if any influence is exerted by the nitrogen in chemical fertilizer after the second year, and even the second year this influence is very slight. With potash and phosphoric acid the case is different, the effect of a large application being felt for many years. This is explained by the fact that nitrogen in the form suitable to be used by plants is readily washed out of the soil, while potash and phosphoric acid combine with the soil, and though not immediately available are gradually made so, and hence in time will be largely recovered.

Where lands are greatly worn by years of cropping, more fertilizer should be used to the acre, and it should contain about equal parts of cotton-seed meal and high-grade acid phosphate. The beneficial effect of commercial fertilizers depends largely upon the presence of humus in the soil; hence the importance of using stable manure and plowing under green crops. In applying the foregoing instructions the farmer must use considerable judgment and modify his practice where necessary to fit local conditions.

Before applying commercial fertilizers prepare the soil thoroughly. Where 500 pounds of fertilizer or less is used for cotton put it all out in one application in the furrow about 10 days before planting and mix well with the soil. Where 600 or more pounds per acre are used two applications should be made, one-half in the furrow before planting and the remainder as side applications at the first or second working of the crop. When using 1,000 pounds or more, make two or more applications or broadcast the entire amount before planting.

Where more than 200 pounds of fertilizer is used for corn on thin soil two applications are recommended, 200 pounds in the furrow before planting and the remainder as a side application when the corn is about a foot high. On medium or rich soils all the fertilizer may be applied around the corn. The depth to which the commercial fertilizer is applied is important. Experiments have shown that 3 inches is about the proper depth in all except semiarid sections, where it should be put deeper. It has been a common practice among farmers to apply fertilizers too deep.



Map of Great Plains Area, Showing Annual and Seasonal Rainfall. Dept. of Agr.

There is much uncertainty among farmers as to the manner of applying fertilizers. Generally they should be sown broadcast and cultivated into the soil. The feeding rootlets are not at the base of a tree or plant, but usually are found some distance from the plant where they form a perfect net-work of rootlets in the soil. If fertilizers are applied just at the base of the plant they do but little good and many times much harm.

Nitrogen in the form of nitrate should not be applied until the beginning of the growing season. If applied too early much may be lost by leaching out of the soil before the crop assimilates it. It is many times best to apply the nitrate in two or three partial applications, say one-third at the beginning of the growing season, one-third three weeks later and the last third two weeks later. Other forms of nitrogen may be applied earlier in the spring.

Phosphoric acid and potash compounds may be applied early in the spring, or even during the fall and winter without danger or loss by leaching out of the soil (except on very sandy soils). It is best to apply those phosphates that contain much water-soluble phosphoric acid early in the spring, for if applied in the fall the phosphoric acid tends to revert and become insoluble. Many times when potash is applied it tends to become fixed near the surface of the soil; it is better, therefore, to apply it early in the spring and as soon as the ground is dry enough to work thoroughly cultivate it into the soil.

KIND OF FERTILIZER TO USE.

The kind of fertilizer to be used should be determined (1) by its composition—that is, whether it is nitrogenous, phosphatic, or potassic in its character, and not by the name of the brand or of the manufacturer; and (2) by the form in which the fertilizer constituents exist in it—that is, by the extent of their availability.

In deciding upon the kind of manure to use, the character of the soil must, of course, be taken into account. Crops grown on soils poor in decaying vegetable matter (humus) are, as a rule, benefited by applications of nitrogenous manures, while those grown upon soils well supplied with this substance are more benefited by phosphates and potash. Upon heavy soils phosphates are likely to be more beneficial than nitrogen, while the reverse is the case of light dry soil. All sandy soils are, as a rule, deficient in potash, while clayey soils contain this element in larger quantities. There are many exceptions to the general rules. The farmer, with the general principles well in mind, must use his intelligence in applying them to his conditions.

The Cereals and Grasses.—The cereals (Indian corn excepted) and grasses are quite similar in their habits of growth, and may be regarded as a class distinguished by extensive root systems and long periods of growth, which enable them to extract the mineral food necessary from relatively insoluble sources, and because of their very rapid development of leaf and stem during a short season just before maturity are unable to make normal growth during this period without an abundance of nitrogen in immediately available forms. This period usually precedes the time of rapid nitrification, hence on soils of good natural fertility the application of nitrogen at the right time and in the form of a nitrate results in a largely increased crop. The fact here stated has led certain eminent scientists to regard nitrogen as a dominant or ruling element for this class of plants, a conclusion which is in the main correct where the limitations are properly understood.

The Leguminous Crops.—Clover, peas, beans, vetches, etc., belonging to the class of plants known as legumes, should also be regarded as a distinct class. They possess powers of acquiring food which, so far as we know, are not common to any other class of cultivated plants. They do not depend altogether upon soil sources for their nitrogen, but draw this element partly from the air, and they make almost ravenous use of the mineral constituents, particularly potash and lime. A knowledge of these facts is not only useful in indicating the kind of manures to be used upon them, viz., an abundance of the mineral constituents only, but suggests that the growth of these crops must result in the enrichment of soils in the expensive element, nitrogen, so essential for crops whose exclusive source of supply is the soil.

Root and Tuber Crops.—These may also be regarded as a class which, because of their habits of growth, are as a rule unable to make ready use of the insoluble mineral constituents of the soil, and hence for full development require an abundance of all the fertilizing constituents in readily available forms. Of the three classes of fertilizing constituents, the nitrogen is especially useful for the slow-growing beets and mangels; phosphates are required in abundance for the turnip; and potatoes, both white and sweet, respond favorably to liberal dressings of potash. Thus, while the fertilizers should contain all three elements, certain of the crops, because of their peculiarities of growth, require certain of them in greater relative amounts and in immediately available forms.

The object of the growth, too, whether for the immature produce or for the fully developed plant, is a matter worthy of careful consideration. In other words, shall the fertilizing be of such a character as to stimulate and force an unnatural and artificial growth, or such as assists in the natural development of the plant? That the specific function of nitrogenous manures is to encourage and even force leaf development is a fact not disputed by the highest authority; hence their use in stimulating unusual growth is of the greatest importance in growing market-garden crops, in order that the tenderness and succulence, which is the measure of quality in most of those products, may be secured.

Orchard Trees.—Fruit trees are slow-growing plants, and therefore do not need quick-acting fertilizers as a rule. They appropriate plant food very slowly, and highly soluble manures, such as nitrate of soda, are liable to be washed out of the soil without being utilized. For this reason the use of nitrate of soda is not advised, except where the growth of nursery stock is to be forced or where bearing trees exhibit a lack of luxuriance in foliage. The old and still common practice of fertilizing fruit trees every few years with slowly decomposing manures, such as barnyard manure, leather waste, horn refuse, wool waste, leaf mold, tobacco stems, etc., is thus seen to have more or less of a scientific basis. Frequently, however, it is desirable to stimulate the growth and fruitfulness of the trees, and for this purpose more active fertilizing materials than the above are needed. In selecting and mixing the latter, the fact that fruits are "potash feeders" should be taken into consideration.

Probably there is no better fertilizer for fruit trees than a mixture of muriate of potash and ground bone (1 part of the former to 1½ parts of the latter). A good practice is to apply this mixture to clover or some other leguminous crop which is turned under as a green manure, and in addition, where tobacco stems can be obtained cheaply, to apply these about the trees. Wood ashes or cotton-hull ashes may be substituted for muriate of potash, if these products can be obtained at reasonable prices.

Small Fruits.—The fertilizer requirements of small fruits are similar to those of orchard fruits, but being as a rule more rapid growers they can utilize to advantage heavier applications of soluble fertilizing materials and do not derive the same benefit as orchard fruits from slowly decomposing manures.

The importance of taking into consideration all the factors which influence the use of fertilizer can hardly be overestimated. A plant must have each one of the essential fertilizer constituents present in an available form or its growth will be hindered in proportion to the deficiency of the lacking constituent. When the soil is rich in a given fertilizer constituent which is present in an available form, it will not be detrimental to the crop if that constituent is omitted in the fertilizer applied. If, on the other hand, the soil be deficient in a fertilizer constituent that is omitted in the fertilizer, the crop yield will decrease in proportion to the insufficient supply of that constituent. When mixing fertilizer for the different crops, the amount of fertilizer which has been added to the soil in barnyard manure, green manures, and leguminous crops should be considered, and no more of any one fertilizer constituent should be applied than is likely to be beneficial. A crop is not benefited by supplying it with more fertilizer than is needed. An excess of one or more fertilizer constituents not only fails to increase but often decreases the yield of crops, as shown both by experiments and by field practice.

To properly adjust the fertilizer constituents the farmer must study his conditions. No definite quantity or proportion of fertilizer constituents can ever be given that will meet the needs of a crop under all conditions. The rotation of crops, the growing of legumes, the use of crops for green manuring, the application of barnyard manure, the methods of preparation and cultivation, and the character of the soil will always be factors which must be taken into consideration when using commercial fertilizer.

The kind and quantity of fertilizer required to produce the most economical yields are greatly influenced by the rotation of crops. Tobacco, for example, takes from the soil approximately ten times as much potash as phosphoric acid, while wheat requires very nearly as much phosphoric acid as potash. The cereals, grasses, and corn are all heavy consumers of nitrogen, while the legumes may gather most of their supply of nitrogen from the air. Turning under the leaves, roots, and stems of legumes also adds a supply of humus to the soil, which is essential for the maximum effect of fertilizers. By growing crops in rotation which have different fertilizer requirements the heavy drain on the soil for any one kind of fertilizer is avoided. If legumes are grown in the rotation, as cowpeas after corn or crimson clover after cotton, then the quantity of nitrogen which need be applied in fertilizers to the corn and cotton can be greatly lessened, and in some cases dispensed with entirely, while the increased humus content of the soil, due to the plowing under of the legumes, makes more efficient the fertilizers that are applied.

A rotation, therefore, which is planned to minimize the need of commercial fertilizer should include crops of different fertilizer requirements alternating with those which add humus and nitrogen to the soil. Rotations which do not include crops that improve the humus content or add nitrogen to the soil need not be expected to reduce the fertilizer bill.

RESULTS WITH CERTAIN CROPS.

It has been shown by certain experiments with nitrate of soda on a number of different crops that, whereas the grain and forage crops, utilizing the nitrate as completely as did the market-garden crops in the same experiment, showed an increase not exceeding in any case a value of $14 per acre, that is, a money return at the rate of $8.50 per 100 pounds of nitrate used, the market-garden crops yielded an increase whose value amounted in the case of one crop to as much as $263 per acre, which was equivalent to a return of approximately $66 per 100 pounds. The striking difference in the returns may easily be accounted for by the fact that in the one instance the nitrate nitrogen was built into bulky crop, consuming large quantities of plant food, and possessing a low market value—dry hay, bringing, say, $12 per ton, and two tons per acre being considered a good yield—while in the other it was built into a material possessing a high market value—succulent vegetables, bringing as much as hay per ton and the yield being five to ten times as great. It is evident, therefore, that these relations of the cost of fertilizer and of the value of the crop returns are exceedingly important, and deserve careful consideration in the purchase of plant-food constituents. It is for this reason that it is so difficult to secure a reasonable profit from the unsystematic use of fertilizers upon such staple products as wheat, corn, oats, cotton, and tobacco—crops quite exhaustive in their manurial requirements and possessing a relatively low value.

On the other hand, the growth of such crops as potatoes, tomatoes, sweet potatoes, forage crops for the dairy, and vegetable crops for the market or cannery by the use of high-priced plant food is more often attended with profit because they are usually crops of high market value and are proportionately less exhaustive.

In the case of such market-garden crops as tomatoes, cabbage, turnips, beets, and others, earliness and quality are important considerations. To be highly remunerative they must be harvested early; in other words, they must be forced—that is, their growth hastened at a time of the year when the decomposition processes in the soil are proceeding but slowly; hence the value of such substances as nitrate of soda. The edible quality of these products is likewise dependent in great measure upon uniform and rapid growth, and for this reason a supply of plant food in reasonable excess of ordinary demands is essential in order to counteract, so far as possible, the unfavorable conditions of season. This should not be construed to mean, however, that the crops of lower commercial value should be abandoned, but rather that our systems of practice shall be changed so as to include in the rotation some high-priced crop, to which shall be applied such an abundance of plant food as to insure a yield, limited only by the season and climate, which will under average conditions of soil and season return a profit besides leaving a residue of plant food for the cereals, grasses, or catch crops that follow. These, being capable of extracting their mineral food from relatively insoluble sources, will yield a large increase of crop without a direct outlay for fertilizers. Farming will thus be more successful, because profitable crops are secured, while fertility is at the same time increased.

Definite rules can not be given as to quantities of commercial fertilizers to be applied, as the amounts necessary to produce large crops will vary with the character and the state of fertility of the soil, the kind of crop to be grown, the time and manner of application, and other conditions. For ordinary farm crops 500 pounds per acre may be considered a heavy application; applications of half a ton or more will only give economical returns in the case of special crops grown under an intensive system of farming. Farmers who expect to use commercial fertilizers on their land are advised to make applications on a small area at first, at the rate of about 200 pounds per acre, or at different rates per acre, so that they may gain some experience as to the best methods of applying the fertilizers and as to the profitableness of the applications on their land, before they spend much money for these. The poorer the soils on which commercial fertilizers are used, the better returns may, in general, be expected. Lime may be applied at the rate of 1,000 pounds per acre on light soils, and double this amount on heavy soils, in the sections where this constituent is likely to produce an increase in production.

THE PURCHASE OF FERTILIZERS.

As a rule, farmers are inclined to purchase fertilizers on the ton basis without sufficient regard to the amount or form of the constituents contained in them. The direct value of a fertilizer is determined by the percentage of nitrogen, phosphoric acid, or potash which it contains; hence, the buying of a fertilizer is virtually the buying of one or more of these constituents. The more concentrated the material or the richer it is in plant food, the less will be the proportionate expense of handling the constituent desired. The following are illustrations of the methods by which brands may be made up, the differences that may exist in the content of actual fertilizing constituents, and the causes of variation in ton prices:

Formula No. 1.

	Pounds.		Pounds.	P. ct.
Nitrate of soda	500,	furnishing nitrogen	80, or	4
Boneblack superphosphate	1,100,	furnishing phosphoric acid	180, or	9
Muriate of potash	400,	furnishing potash	200, or	10
Total	2,000,	furnishing total plant food	460	

Formula No. 2.

	Pounds.		Pounds.	P. ct.
Nitrate of soda	250,	furnishing nitrogen	40, or	2
Boneblack superphosphate	1,000,	furnishing phosphoric acid	160, or	8
Muriate of potash	80,	furnishing potash	40, or	2
Make-weight	670			
Total	2,000,	furnishing total plant food	240	

Formula No. 1 shows a high-grade product, both as to quality of plant food and concentration, while No. 2 is high grade only in quality. In the latter it is necessary to add what is called make-weight, or a diluent, usually consisting of substances that are of no direct fertilizing value, in order to make up the weight to 1 ton.

High-grade mixtures can not be made from low-grade materials. Low-grade mixtures can not be made from high-grade materials without adding make-weight. The advantages of high-grade products are concentration and high quality of plant food.

It will be observed that formula No. 1 contains nearly twice as much plant food as No. 2; or, in other words, it will require the purchase of about 2 tons of a fertilizer made according to formula No. 2 to secure the same total amount of plant food as is contained in 1 ton of No. 1. Now, the material in No. 2, other than the actual plant food, possesses no direct fertilizing value; but the actual cost of the constituents is considerably increased, because the expenses of handling, bagging, shipping, and selling are just double what they would be for No. 1.

As a rule that has but few exceptions, the more concentrated the materials from which the fertilizer is made the more suitable (or less objectionable) they are as food for plants. High-grade sulphate and high-grade muriate of potash are more concentrated than the lower grades, and correspondingly more acceptable to plants. The high-grade sulphate contains nothing objectionable to any plant. It is all that could be asked of a potash fertilizer. In the muriate the potash is associated with chlorine, a material objectionable to the majority of crops, and especially (and unfortunately) to some of the crops requiring potash in largest quantities. The amount of chlorine in real high-grade muriate is small, being considerably less than the amount of actual potash, and may be used on the great majority of crops with most excellent results. Lower grades of potash materials must be used with greater care.

Passing down the list of potash materials from high-grade sulphate and muriate to low-grade manure salts and kainit, the chlorine increases with the inferiority, so that the grade of a potash material, from an agricultural or any other standpoint, may be pretty well established by the amount of chlorine it does not contain.

There is one reform that is much needed in the purchase of fertilizers, and that is a change from the almost universal practice of buying on the flat ton rate. When fertilizers are bought on this basis, farmers often pay practically the same price for different fertilizers whose compositions necessarily make their commercial values vary considerably, and one may rest assured that he pays too much for the brand of lower value instead of too little for the brand of higher value. The brand or name stands for what the manufacturer thinks is best suited for the crop for which the brand is intended, or else it stands for what the manufacturer wishes the farmer to think is best suited for his crop, in order that the manufacturer may dispose of, at best advantage to himself, fertilizing materials on which he has a corner, or which he can procure on more favorable terms than others. It is too often the case that the immediate financial returns influence the agent's theory of fertilization. Thus it is that some dealers will declare that experience has definitely settled it that organic nitrogen from animal sources is best for most, if not all, crops, and these are the dealers who are directly or indirectly interested in the packing industries. On the other hand, some are very positive that nitrate of soda should be the source of the greater part of the nitrogen, and investigation might disclose the fact that nitrogen in nitrate of soda is the cheapest form for this class of manufacturers. Some will declare with authority that superphosphate made from phosphate rock is superior to superphosphate made from bone, and vice versa (when there is no difference), and one does not have to look very far to find that each party is interested in the material which he advocates. Still others will say that non-acidulated bone is the best form of phosphoric acid, and it would not be surprising to find that the dealer in this class finds greater profit in handling untreated bone, or else that he is not prepared to acidulate his materials.

EFFECT OF FERTILIZERS ON THE PROPORTION OF GRAIN TO STRAW OR STOVER.

It is a matter of common observation that the proportion between the grain and straw is considerably influenced by the season, the soil upon which the crop is grown, and the variety. It is well known also that the kind and amount of fertilizer used exert an important influence upon this point. In connection with a rotation experiment at the Pennsylvania station extending over twelve years, the effect of different fertilizers upon the relation of grain to straw or stover was studied more or less incidentally.

In these experiments the following fertilizers were used singly and in various combinations: Dried blood, dissolved boneblack, muriate of potash, nitrate of soda, sulphate of ammonia, barnyard manure, lime, ground limestone, plaster, and ground bone. The results, summarized by the station, indicate that in the case of corn the average for 24 different fertilizers was 51.8 pounds of stover (stalks without ears) for each bushel of unshelled corn (70 pounds). The average proportion for the 7 complete fertilizers was 55.4 pounds of stover per bushel of corn, and of these barnyard manure gave the smallest proportion of stover to ears (47.6 pounds,) and the complete fertilizer containing dried blood the largest (58.1 pounds.) Complete commercial fertilizers materially increased the proportion of stover to ears as compared with barnyard manure.

In the case of oats, however, the largest relative yield of straw was from the barnyard-manure plats, which showed about 10 per cent more straw in proportion to the grain than the plats receiving complete commercial fertilizers. The average for the 24 different fertilizers was 45 pounds of straw per bushel of oats (32 pounds) and the average for 7 complete fertilizers was 42 pounds of straw, of which barnyard manure gave the largest proportion (46.2 pounds). Complete fertilizers containing sulphate of ammonia gave about 7 per cent more straw in proportion to grain than either nitrate of soda or dried blood.

With wheat the average proportion of straw for all the plats was 101 pounds per bushel of grain (60 pounds). Complete fertilizers increased the proportion of straw, and among them barnyard manure showed the least increase and sulphate of ammonia the greatest.

Except in the case of corn, increasing the amount of nitrogen per acre (24, 48, and 72 pounds) regularly increased the amount of straw to a bushel of grain. While these relations of fertilizers to the proportions of grain and straw may not hold good under all conditions, they are interesting as showing the way in which different fertilizers may affect the relation through a series of years, and may have a bearing in the selection of fertilizers.

HOME-MIXED FERTILIZERS.

In many cases it is desirable to purchase the unmixed fertilizing materials, either for use singly or for home mixing. Here a great saving may be effected (1) in the cost per pound of the constituents, (2) in freight rates, and (3) in having the mixing performed by the ordinary labor of the farm at times when it does not interfere with regular outdoor work. The advantages to be derived from this method are, however, fully realized only when it is possible to purchase fertilizers in large quantities and for cash.

As an illustration of the saving that may be thus effected, it is but necessary to cite the experience of a farmers' organization in New Jersey, which now purchases annually some 800 to 1,000 tons of unmixed goods at a cost per pound of the ingredients from 25 to 40 per cent less than the average cost to those who buy the average mixture in small quantities on time from their local dealers.

It has been shown, too, by the studies of many of the experiment stations of both the East and South that the materials can be evenly mixed on the farm; besides, samples carefully taken show as good a mechanical condition as those made by the leading manufacturers.

This method of purchasing also possesses the further advantage of enabling the farmer to apply just the kind and form of ingredient that he has found by experience or experiment to be best adapted to his soil and crop. Besides, he knows positively, particularly in case of the element nitrogen, whether it is in the form of nitrate, ammonia, or organic matter, and whether the organic nitrogen is contained in substances that are likely to decay quickly, as blood, cottonseed meal, etc., or in such insoluble and slowly acting substances as ground leather, horn, etc. In mixtures the kind of organic nitrogenous substances used can not be definitely shown by a chemical analysis.

Whether or not it is profitable to prepare home mixtures of fertilizers depends upon conditions. The question can be answered by any one who desires by calculating the cost of the unmixed materials and after allowing for the cost of mixing, compare the results with the price at which the mixed fertilizers could be purchased. The quantity of each ingredient to be used in making the mixture must, of course, be known, and the cost of the ingredients, including freight charges, must also be ascertained. It may be said further in favor of home mixtures that the grade of material used is known. It is also easy to vary the mixture for the purpose of testing the effect of different combinations upon the soil.

The probable reason that more farmers do not buy the chemicals and mix their fertilizer according to the needs of their farms and the crops to be grown is that they do not know how to combine the chemicals in order to produce the required mixture. This need not give one any difficulty if a little study be given the subject. If it has been found that good results have been secured with a certain mixed fertilizer, then those chemicals should be purchased and mixed which will give a similar proportion of plant-food.

The mixing of fertilizers on the farm can be done very satisfactorily by emptying the raw materials on a tight floor of wood or concrete; or if more convenient it may be done on a hard dirt floor under a shed or outhouse. It is better not to empty over 400 to 600 pounds at one time, as it can be more readily and thoroughly mixed in small quantities. The mixing can be done with hoes and shovels by turning over two or three times and continuing this process until the desired quantity is ready for use. This method of home mixing is very desirable where the farmer wishes to leave out any element or in any way change the proportion to better suit special conditions.

The only tools necessary for home-mixing are a square-pointed shovel, a broom, an ordinary 2x6 sand screen with three meshes to the inch, a wooden tamper and a pair of platform scales,—the latter are not absolutely necessary when mixing large quantities because the materials come in bags of a known and fixed weight. Put the materials together in a pile on a clean barn floor, placing the most bulky ingredient on the bottom and the least bulky on top. Turn over with the shovel into cone-shaped piles about three times, or until the mixture has a uniform color. Then throw it through the screen to remove the lumps and to complete the mixing; the lumps may then be mashed with the tamper and rescreened. The mixture is now ready for bagging and use, and if care has been exercised in selecting the materials it will not cake or deteriorate.

The following series of formulae for home mixed fertilizers is highly recommended by the Texas Experiment Station. The farmer knowing the special needs of his soils can from these readily choose the fertilizer that will give the best returns.

Formula I.—8-2-2 Fertilizer.

This fertilizer contains 8 per cent available phosphoric acid, 2 per cent potash and 1.65 per cent nitrogen. It may be prepared by mixing the following ingredients:

Acid phosphate, 14 per cent	1170 pounds.
Cottonseed meal	490 pounds.
Kainit	340 pounds.
Total	2000 pounds.

Formula II.—8-2-2 Fertilizer.

Acid phosphate, 14 per cent	900 pounds.
Tankage	560 pounds.
Kainit	340 pounds.
Filler	200 pounds.
Total	2000 pounds.

This formula differs from formula No. I in that the nitrogen is secured from tankage instead of from cottonseed meal. The tankage is assumed to contain 6 per cent of nitrogen, and 6 per cent of available phosphoric acid. If its composition were different, the formula of the mixture would, of course, be different.

Any indifferent material can be used as a filler. In home mixing, however, it would be unnecessary to use a filler. Simply apply less of the fertilizer.

Formula III.—8-3-3 Fertilizer.

Acid phosphate, 14 per cent	1170 pounds.
Cottonseed meal	730 pounds.
Muriate or sulphate of potash	100 pounds.
Total	2000 pounds.

This fertilizer contains 8 per cent available phosphoric acid, 3 per cent of potash, and about 2.5 per cent nitrogen. It may be used on cotton or corn, or on vegetable crops that do not require much potash or nitrogen.

Formula IV.—8-3-3 Fertilizer.

Acid phosphate	1000 pounds.
Cottonseed meal	650 pounds.
Nitrate of soda	100 pounds.

Muriate or sulphate of potash	100 pounds.
Filler	150 pounds.
Total	2000 pounds.

This fertilizer has the same composition as No. III, but contains about one-fourth of its nitrogen in the immediately available form of nitrate of soda. This would be ready to give the plant a rapid start.

Formula V.—8-3.6-4 Fertilizer.

Acid phosphate, 14 per cent	1100 pounds.
Cottonseed meal	430 pounds.
Nitrate of soda	200 pounds.
Muriate or sulphate of potash	160 pounds.
Total	2000 pounds.

This fertilizer is used for truck crops, potatoes and other crops requiring more nitrogen than corn or cotton requires. One-half of the nitrogen is in the active form of nitrate of soda. If desired, the 200 pounds of nitrate of soda could be replaced by 430 pounds of cottonseed meal; this alters the composition of the fertilizer and the nitrogen is not so immediately available, but it is less likely to be washed out.

Formula VI.—8-4 Fertilizer.

Acid phosphate, 14 per cent	1100 pounds.
Cottonseed meal	900 pounds.
Total	2000 pounds.

This fertilizer does not contain any potash except a small quantity in the cottonseed meal. It is used for potatoes in some parts of the State.

Formula VII.—10-2 Fertilizer.

Acid phosphate, 14 per cent	1500 pounds.
Kainit	350 pounds.
Filler	150 pounds.
Total	2000 pounds.

This fertilizer contains 10 per cent phosphoric acid and 2 per cent potash, and it is used when no nitrogen is desired.

Formula VIII.—10-4 Fertilizer.

Acid phosphate, 14 per cent.	1500 pounds.
Muriate or sulphate of potash	170 pounds.
Filler	330 pounds.
Total	2000 pounds.

This fertilizer contains 10 per cent of phosphoric acid and 4 per cent of potash.

In the above formulas acid phosphate containing 14 per cent available phosphoric acid is used. If acid phosphate containing 12 per cent phosphoric acid is used, the percentage of phosphoric acid will be correspondingly reduced. If 16 per cent acid phosphate is used, the percentage of phosphoric acid will be increased.

List of Materials Used in Home-Mixing of Fertilizers.

Name of Material	Per cent. of Nitrogen	Per cent. of Phosphoric Acid	Per cent. of Potash	Availability
Nitrate of soda	15.	0	0	very quick
Sulphate of ammonia	20.	0	0	quick
Dried blood	10.	0	0	medium
Tankage (9 20)	7.4	10	0	slow
Tankage (6-30)	5.	15	0	slow
Ground bone	2.5	23	0	slow
Acid phosphate 14 per cent	0	14	0	quick
Acid phosphate 12 per cent	0	12	0	quick
Dis. bone black	0	15	0	medium
Basic slag	0	15	0	slow
Rock phosphate	0	18–30	0	very slow
Muriate of potash	0	0	50	quick
H. G. Sul. of potash	0	0	50	quick
Kainit	0	0	12	quick
Wood ashes	0	2	6	medium

Do Not Buy Recipes For Making Fertilizers.—From time to time parties go around selling formulas for fertilizers which they claim to be "secret" or "wonderful discoveries." Most of the recipes that have been sold in this way are worthless. Mixtures prepared according to the directions given are not worth the time and labor applied to them. Ingredients are called for which can only be purchased at high prices and likely as not are wholly without value to the plant or the soil. The following is an example of a fertilizer recipe which has been offered for sale:

Bluestone	2 pounds.
Saltpeter	2 pounds.
Nitrate of ammonia	2 pounds.
Soda ash	2 pounds.
Potash ball	4 pounds.

Dissolve in five gallons of water and sprinkle on the sand; make a ton sufficient for one acre. Not a single one of the substances mentioned is used in making fertilizers. Bluestone and soda ash do not contain any plant food. Saltpeter, ammonium nitrate, and potash contain potash and nitrogen, but they are too expensive to be used as a fertilizer. The potash would act upon the ammonium nitrate and drive off the ammonia, making the mixture smell like ammonia. The smell would not grow any plants. The mixture would contain about 3 pounds of potash, and 1 pound of nitrogen and would have a fertilizer valuation of 33 cents per ton. It would cost from $1.50 to $2.00 for the ingredients.

Authorities Consulted.—W. Va. E. S. B. 51, 80; W. Va. E. S. B. 114; Wash. E. S. B. 114; Tex. E. S. B. 85; Univ. Tenn. B. 1; Univ. Tenn. Rept. 1899; N. C. E. S. Rept. 1887; Penn. Col. B. 35; Ore. E. S. B. 79; O. E. S. Bs. 54, 79, 167; Cornell Univ. B. 201; N. Y. E. S. B. 192; N. H. E. S. Bs. 5, 12, 21; Miss. E. S. B. 99; Purdue Univ. B. 10; Univ. Ill. Bs. 116, 129; Conn. E. S. Repts. 1900, 1902, 1903, 1907; Univ. Calif. Bs. 157, 178, 179; Bu. Plt. Ind. Bs. 441, 692; F. Bs. 56, 398; Mass. Ag. Col. B. 9; F. Bs. 44, 245, 192; Univ. W. Va. Bs. 28, 99, 112; Ala. Dept. Ag. B. 2; Bu. Soils B. 58; Univ. Wis. B. 180; W. Va. E. S. B. 40; Tex. E. S. B. 112; La. E. S. B. 31;

Clemson Col. B. 21; R. I. E. S. Bs. 71, 90, 95, 104, 106, 112, 118; O. E. S. Bs. 114, 168; N. H. E. S. Bs. 26, 88, 97, 108, 140; Purdue Univ. B. 88; Univ. Ill. B. 130; Mass. Col. B. 45; Md. E. S. B. 128; Fla. E. S. B. 20; Colo. Ag. Col. B. 168.

SPECIAL FERTILIZING.

Owing to the variations in soil and climatic conditions it is impossible to give any fixed rule for fertilization of any special crop, either as to the formula of the fertilizer, time of application, amount to be applied, or manner of application. A fertilizer that might succeed well in Texas might prove a failure in Minnesota. A fertilizer might succeed on one field in a State and fail of satisfactory results on another. All the Experimental Stations have conducted experiments looking to solving the problem and finding the best fertilizer for each crop on soils of the same general characteristics, but the results of the experiments vary largely. It should be again emphasized that the first requirement to be successful in growing any crop and the use of any fertilizer is for the farmer to know the condition of his soil, what plant foods it contains and their availability for the use of the crop he desires to grow.

Cotton.—In reviewing the results of the experiments conducted at or under the auspices of the experiment stations, and taking into account the general experience of successful cotton growers, certain general conclusions on the subject of the fertilization of cotton may be accepted as tentatively established:

(1) Cotton is a plant which responds promptly, liberally, and profitably to judicious fertilization.

(2) By judicious fertilization the maturity of the crop may be hastened and the period of growth, from germination to fruiting, so shortened as to materially increase the climatic area within which cotton may be profitably grown.

(3) As is the case with most other crops, the profit from manuring cotton with concentrated fertilizers is much enhanced by antecedent proper preparation of the soil. It pays to bring cotton lands up to a condition of good tilth by mechanical treatment, and especially by incorporating in them liberal quantities of organic matter. Upon lands in such condition fertilizers of all kinds yield more profit, either from small or large applications, than upon lands not so treated.

(4) Renovating crops, and especially the cowpea, furnish an efficient and economical method of bringing cotton lands into condition to respond most liberally and profitably to the application of concentrated manures under cotton. The most profitable plan of employing the cowpea for this purpose on cotton is to gather the peas at maturity, cut the vines for hay, and turn under the stubble along with the manure resulting from feeding the hay to stock and cattle.

(5) Barnyard manure and similar bulky manures are more efficient and profitable as soil renovators than as specific fertilizers for cotton. They should be broadcast liberally and used rather as soil improvers than as immediate fertilizers. The same is probably true of cotton seed, except where the price to be had for the seed

at cotton-oil mills justifies the exchange of seed for cotton-seed meal, to be used as the source of nitrogen in a concentrated manure. If, however, only small quantities of such manures are to be had, and it is desired to use them as direct fertilizers, it is more profitable to compost them with acid phosphate (preferably containing a small percentage of potash) than to use them alone. It is more profitable to compost directly in the drill at time of planting than in heaps previously.

(6) Cotton may wisely be assigned a place in a judicious rotation system. Upon lands devoted to staple crops a three years' rotation—small grain, corn (with peas,) cotton—is judicious. Each crop in the rotation should be appropriately fertilized. It is in evidence that the cumulative effects of such manuring upon the succeeding crop are marked.

(7) Upon the great majority of the soils of the cotton-growing States it is advisable and profitable to use, as a concentrated fertilizer, a complete manure, i. e., one containing soluble phosphoric acid, available potash, and available nitrogen, rather than a manure containing only one or two of these ingredients. Nitrogen, however, may probably be advantageously omitted from the concentrated fertilizer, in whole or in part, when the soil has previously been liberally supplied with this ingredient, through barnyard manure, green manuring, etc.

(8) Soluble phosphates are very much to be preferred in the fertilizer for cotton to those which are not soluble.

(9) There is no great difference, if any, in the agricultural value and profit, when used in the fertilizer for cotton, of the various soluble potash salts to be had in commerce, except proportionately to the price and content of actual potash.

(10) Of the nitrogen compounds available for use in fertilizers the organic forms (vegetable and animal) are perhaps best suited to cotton, if one form alone be used, although nitrate of soda is probably nearly if not quite of equal value. Further experiments are needed to determine the efficacy of mixing various nitrogen compounds in different proportions.

(11) The most judicious proportions of soluble phosphoric acid, potash, and nitrogen in a complete fertilizer for cotton can not be said to have been as yet determined with entire accuracy. Those suggested by Georgia—nitrogen 1, potash 1, phosphoric acid 3½—and by South Carolina—nitrogen 1, potash ¾, phosphoric acid 2¼—perhaps approximate reasonable accuracy. In the light of present information, perhaps nitrogen 1, potash 1, phosphoric acid 2¾ or 3 would not be injudicious proportions for general use.

(12) The amount of concentrated fertilizer which may profitably be used per acre varies widely with the nature and condition of the soil, the seasons, and other circumstances. For an average soil in fairly good condition perhaps the maximum amounts indicated by Georgia (nitrogen, 20 pounds; potash, 20 pounds; phosphoric acid, 70 pounds), or by South Carolina (nitrogen, 20 pounds; potash, 15 pounds; phosphoric acid, 50 pounds), or an

approximate mean of the two would be the maximum limit of profitable application. The actual weight of the complete fertilizer furnishing these quantities would, of course, vary with the percentage composition in nitrogen, potash, and phosphoric acid of the materials used to make the fertilizer. If the commercial "ammoniated" fertilizer or other concentrated manure intended for use under cotton should be compounded (as it might very well be, and in some cases is) to analyze approximately—

	Per cent.
Soluble (available) phosphoric acid	9
Potash	3
Nitrogen	3

then 700 pounds per acre of such a fertilizer would be approximately the maximum amount that could judiciously and profitably be used, under ordinary circumstances, upon soil in good condition.

(13) The concentrated fertilizer should be applied in the drill (not broadcast) at a depth of not more than 3 inches, and well mixed with the soil.

(14) All things considered, it is perhaps best in most cases to apply all the concentrated fertilizer in one application at the time of planting. With lands in superior condition, however, or where large quantities of fertilizers are used, it is probably profitable to apply half at planting and half at the second plowing.

Yield From the Use of Fertilizers on Cotton as Compared With Yield from Unfertilized Soil.—The results of experiments instituted vary greatly with the nature of the soil, the seasons, the culture, and the kinds and amounts of manures employed. With the exception of those upon one class of soils, however, they all agree in demonstrating that large profit attends the judicious manuring of cotton. The exception is in the case of the black prairie or canebrake soils of the alluvial formations of the Gulf States. Experiments upon such soils at the Alabama stations indicate that no compensating returns may be expected from the use of manures except crushed cotton seed and cotton-seed meal, and even with these the returns are small. Drainage and good mechanical tillage seem to be the chief need of these soils. Upon other soils of Alabama, however, the percentage of profit from a judicious use of fertilizers, followed by intelligent cultivation, is most satisfactory. Upon a poor sandy soil, with no retentive clay within 3 feet of the surface, even with unusual expense for fertilizers, the increase resulting from the use of economical manures paid 85 per cent profit on cost.

Experiments made under direction of the Arkansas Station indicate that fertilizers are generally remunerative, the percentage of profit ranging from 20 to 180. Five hundred pounds per acre of rotted cotton seed gave a net profit of $3.93. Five hundred pounds each of cotton seed (at $6.50 per ton) and cotton-seed meal (at $20 per ton) gave equal financial profit.

At the Georgia Station the use of commercial fertilizers was almost always profitable, the percentage of profit ranging from 5 to 250. The stations of Louisiana, Mississippi, North Carolina, and South Carolina obtain similar results from experiments, and indicate that the application of fertilizing material to cotton seems, with few exceptions, to be profitable.

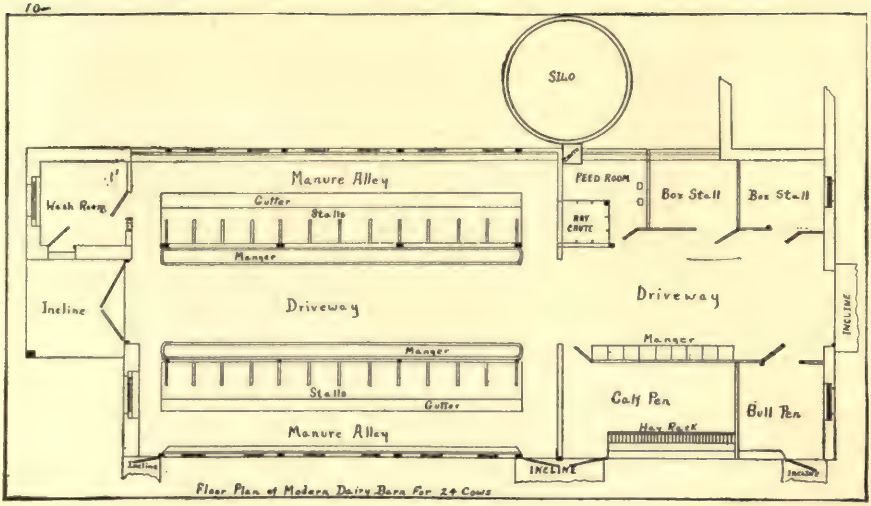
To the teaching of these specific experiments may be added the general experience of the great bulk of the cotton planters, and it may be accepted as proven that cotton responds favorably to artificial manuring, and that upon most of the soils of the cotton States all kinds of manures, including concentrated commercial fertilizers at the prices at which they are commonly held, are profitable when judiciously used.

Comparative Values of Commercial Fertilizers and Home Manures.—Results of experiments on this point also vary considerably with the soil and season. In Alabama green manuring appears to have been most profitable upon both prairie and sandy soils. Peas and melilotus both gave good results; pea vines appeared to be the best fertilizer for cotton; peas were more economical for green manuring for one season, melilotus for two; stable manure generally gave good results, lasting in effects; upon canebrake soils, both drained and undrained, crushed cotton seed and stable manure each gave small returns, commercial fertilizers none. Upon a field with sandy soil which had not been cultivated for many years stable manure, contrasted with chemical manures of various kinds and in various proportions, produced the largest increase and the largest profit per acre, but it was noted that the amount applied was at the rate of nearly 2 tons per acre, or one-half ton more than the amount annually saved from each mule kept.

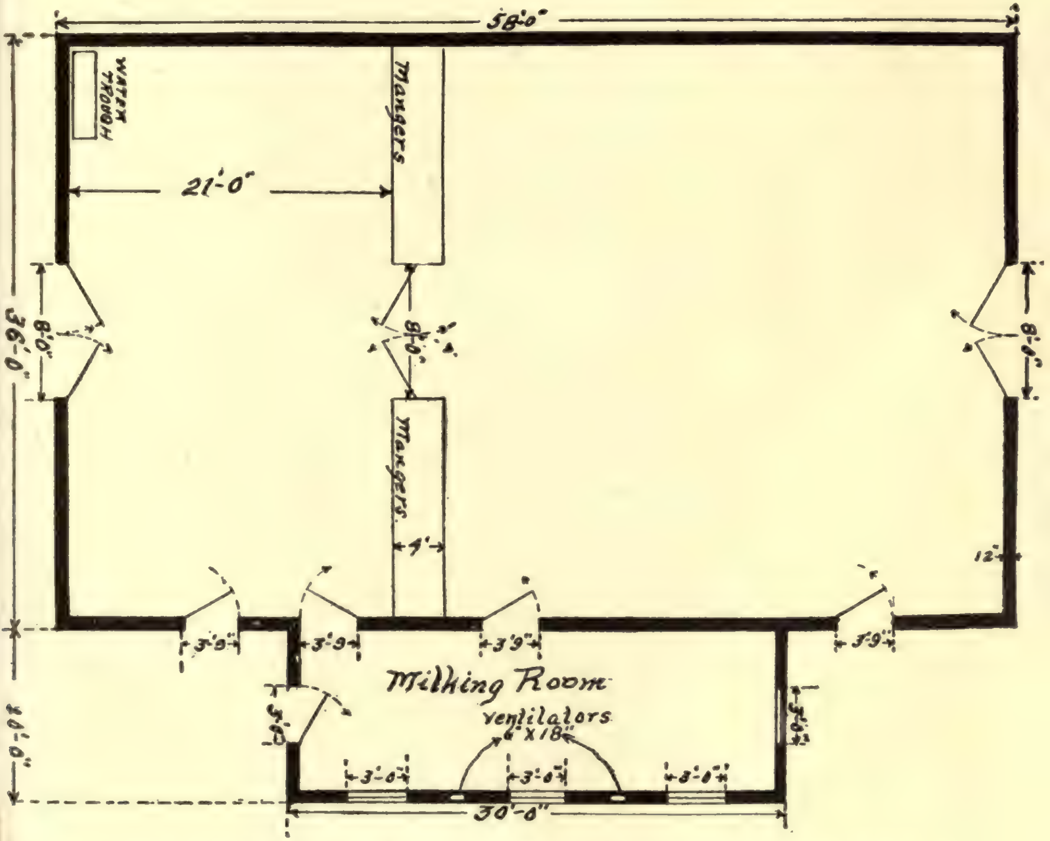
In Arkansas, cotton seed and cotton-seed meal gave best results when tested against acid phosphate and kainit separately. On worn sandy bottom lands almost continuously planted in cotton for thirty years cotton-seed meal and stable manure each gave better results than chemical manures, and better results when used alone than when mixed with acid phosphate and kainit. Other experiments indicated, however, that stable manure (from feeding cotton seed and pea-vine hay) extended the growing season of the plant, delayed maturity of the crop, and hence decreased the possible yield and profit.

In Georgia, cotton seed and stable manure alone were found unprofitable as compared with the same composted with acid phosphate, and gave less profit, when used in amounts of equal cost, than chemical manures. In Louisiana, cotton seed and stable manure alone were of doubtful profit as compared with chemical manures. Manure from the farm should be re-enforced with cotton-seed meal and composted with acid phosphate. The compost is the best manure in the world for cotton. The formula recommended for the compost is—

Green cotton seed	bushels..	100
Stable manure	do....	100
Acid phosphate	pounds..	2,000



Floor Plan of Modern Dairy Barn For 24 Cows



Floor Plan of Maryland Experiment Station. Open Stable. Dept. of Agr.
(See page 122.)

Almost as effective as the compost was a homemade chemical manure, constructed as follows:

	Pounds.
Acid phosphate	1,100
Cotton-seed meal	700
Kainit	200

In Mississippi, commercial fertilizers were more profitable than stable manure or cotton seed alone, but paid best in connection with an abundance of organic matter. Composts variously proportioned gave best results.

In North Carolina, barnyard manure was found to be especially effective, partly on account of its after effects, and somewhat the best of all fertilizers. Its first cost, however, detracted from the profit, and a combination with acid phosphate was much more profitable. Home composts gave generally good results, and next to these a home mixture of—

	Pounds per acre.
Acid phosphate	200
Cotton-seed meal	100
Kainit	50

Relative Availability of Plant Food in Seed and Meal.—There is a difference in the mechanical condition and the chemical composition of seed and meal, and owing to these differences a season which is entirely suited to one is not likely to be very favorable to the other. The seeds are incased in hulls which must decay before the crop can utilize the plant food in them, and the kernels contain oil which is supposed to retard their decomposition, so that considerable moisture is required to decompose the seed and make available the plant food. In case of a very dry season it does not become available fast enough to supply the crop, and no doubt a portion of it fails to become available until after the crop has matured. On the other hand, the fertilizing material in meal, being in a finely pulverized condition, is more likely to become available during a dry season than that in seed; but when there is excessive rainfall it is liable to become available so fast that the crop can not utilize it and a portion of it will likely be leached out and wasted. It seems, therefore, that seed has an advantage over meal during wet seasons.

The Amount of Fertilizers Per Acre Giving Best Results.—The experiments bearing upon this question are somewhat meager and the results uncertain. The amount of fertilizer which may be judiciously and profitably employed is shown clearly to depend upon the character, condition, and previous treatment of the soil, and to some extent upon the season. Very few systematic experiments have been made to test this specific question. In Alabama one series of experiments indicated that an application of 1,000 pounds per acre of a complete fertilizer was not as profitable as one of 500 pounds, although the yield was somewhat increased.

In Georgia large doses of fertilizer applied at planting or during the earlier periods of growth resulted in earlier maturity of the crop, without, however, sensible increase in profit. The results of experiments conducted for several years on series of plats of gravelly gray soils with yellow subsoil, in which fertilizers were applied at the rates of 400, 600, and 1,200 pounds per acre, indicated—

(1) That while heavy doses of fertilizers do not give a corresponding increase in the yield of cotton, or so large a percentage of profit, yet such heavy applications, within reasonable limits, are judicious, provided the land is in good condition.

(2) That the limit or maximum amount of fertilizers that can be safely and profitably applied to land in good condition varies considerably, say from 500 to 1,000 pounds per acre, according to seasons, variety of cotton, etc.

Quantity and Composition of Fertilizer Mixtures Suggested for Application to Each Acre of Cotton Grown on Various Kinds of Soil.

Fertilizing Material.	Quantity of each constituent.	Fertilizer constituents contained in mixture.		
		Phosphoric acid.	Ammonia.	Potash.
SANDY SOIL—FIRST SUGGESTION.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Acid phosphate, 16 per cent	350	56.0	....	....
Cotton-seed meal, 1-7.5-1 per cent [a]	240	2.4	18.0	2.4
Nitrate of soda, 18 per cent	45	....	8.1	....
Muriate of potash, 50 per cent	68	....	....	34.0
(Or 272 pounds of 12.5 per cent kainit.)				
Total	....	58.4	26.1	36.4
SANDY SOIL—SECOND SUGGESTION.				
Acid phosphate, 14 per cent	415	58.1	....	....
Dried blood, 14 per cent [b]	125	....	17.5	....
Nitrate of soda, 18 per cent	50	....	9.0	....
Muriate of potash, 50 per cent	72	....	....	36.0
(Or 288 pounds of 12.5 per cent kainit.)				
Total	....	58.1	26.5	36.0
SANDY LOAM SOIL—FIRST SUGGESTION.				
Acid phosphate, 16 per cent	300	48.0	....	....
Cotton-seed meal, 1-7.5-1 per cent [a]	215	2.2	16.1	2.2
Nitrate of soda, 18 per cent	35	....	6.3	....
Muriate of potash, 50 per cent	56	....	....	28.0
(Or 224 pounds of 12.5 per cent kainit.)				
Total	....	50.2	22.4	30.2
SANDY LOAM SOIL—SECOND SUGGESTION.				
Acid phosphate, 14 per cent	360	50.4	....	....
Dried blood, 14 per cent [b]	115	....	16.1	....
Nitrate of soda, 18 per cent	35	....	6.3	....
Muriate of potash, 50 per cent	60	....	....	30.0
(Or 240 pounds of 12.5 per cent kainit.)				
Total	....	50.4	22.4	30.0
GRAY LOAM SOIL—FIRST SUGGESTION.				
Acid phosphate, 16 per cent	250	40.0	....	....
Cotton-seed meal, 1-7.5-1 per cent [a]	130	1.3	9.8	1.3
Nitrate of soda, 18 per cent	35	....	6.3	....
Muriate of potash, 50 per cent	34	....	....	17.0
(Or 136 pounds of 12.5 per cent kainit.)				
Total	....	41.3	16.1	18.3

[a] Equals 1 per cent of phosphoric acid, 7.5 per cent of ammonia and 1 per cent of potash.

[b] Slaughterhouse tankage may be substituted for dried blood if, on the basis of the weight of plant food contained, it is cheaper.

Fertilizing Material	Quantity of each constituent.	Fertilizer constituents contained in mixture.		
		Phosphoric acid.	Ammonia.	Potash.
GRAY LOAM SOIL—SECOND SUGGESTION.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Acid phosphate, 14 per cent	285	39.9		
Dried blood, 14 per cent *b*	75		10.5	
Nitrate of soda, 18 per cent	30		5.4	
Muriate of potash, 50 per cent (Or 144 pounds of 12.5 per cent kainit.)	36			18.0
Total		39.9	15.9	18.0
RED CLAY SOIL—FIRST SUGGESTION.				
Acid phosphate, 16 per cent	210	33.6		
Cotton-seed meal, 1-7.5-1 per cent *a*	120	1.2	9.0	1.2
Nitrate of soda, 18 per cent	25		4.5	
Muriate of potash, 50 per cent (Or 100 pounds of 12.5 per cent kainit.)	25			12.5
Total		34.8	13.5	13.7
RED CLAY SOIL—SECOND SUGGESTION.				
Acid phosphate, 14 per cent	245	34.3		
Dried blood, 14 per cent *b*	65		9.1	
Nitrate of soda, 18 per cent	25		4.5	
Muriate of potash, 50 per cent	26			13.0
Total		34.3	13.6	13.0

a Equals 1 per cent of phosphoric acid, 7.5 per cent of ammonia and 1 per cent of potash.

b Slaughterhouse tankage may be substituted for dried blood if, on the basis of the weight of plant food contained, it is cheaper.

Quantity and Composition of Fertilizer Mixtures Suggested for Fall and Spring Applications to Each Acre of Wheat Grown on Various Types of Soil.

Fertilizing material.	Quantity suggested.	Fertilizer constituents contained in mixture.		
		Phosphoric acid.	Ammonia.	Potash.
SANDY LOAM SOIL—FALL APPLICATION.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Acid phosphate, 16 per cent	175	28.0		
Muriate of potash, 50 per cent	36			18.0
Total		28.0		18.0
SANDY LOAM SOIL—SPRING APPLICATION.				
Nitrate of soda, 18 per cent	110		19.8	
Total			19.8	
Total, fall and spring applications		28.0	19.8	18.0
GRAY LOAM SOIL—FALL APPLICATION.				
Acid phosphate, 16 per cent	150	24.0		
Muriate of potash, 50 per cent	28			14.0
Total		24.0		14.0
GRAY LOAM SOIL—SPRING APPLICATION.				
Nitrate of soda, 18 per cent	100		18.0	
Total			18.0	
Total, fall and spring applications		24.0	18.0	14.0
RED CLAY SOIL.				
Acid phosphate, 16 per cent	125	20.0		
Muriate of potash, 50 per cent	20			10.0
Dried blood, 14 per cent	114		15.9	
Total		20.0	15.9	10.0

Wheat.—When phosphoric acid and potash are supplied in the fertilizer and sufficient barnyard manure is available to give the land an application of 10 tons to the acre, no ammoniated fertilizer need be applied in the spring. Likewise, when the wheat crop follows a good crop of clover or cowpeas all, or nearly all, the ammonia in the fertilizers applied may be omitted. When the wheat field is seeded to clover or clover and grass and left down for hay, more phosphoric acid and potash should be used than when no hay crop follows. The quantities of the different fertilizer constituents given are intended for wheat under fairly good farming conditions and where the land is not to be seeded to clover and grass.

On old wheat lands phosphate and potash fertilizers can be used to better advantage than either nitrogen alone or a complete fertilizer. If clover is seeded with wheat that has received a dressing of potash or phosphate fertilizer often a better crop of clover results, and thus additional value is secured from the fertilizer. In the building up of old wheat lands the first thing is to determine by trial on a small scale the extent to which commercial fertilizers increase the yield. In case the increase is sufficient to pay for the fertilizer it should be used, as the influence upon following crops will be more than sufficient to pay for the labor.

Commercial fertilizers should be used in connection with crop rotation, farm manures and clover production, rather than as the only means of increasing fertility. When judiciously used they have a proper place in our agriculture, but when indiscriminately used it is generally at a financial loss.

A method of fertilizing corn widely used, and apparently worthy of commendation, in the South Atlantic States is to plant the corn below the level of the soil and cultivate once or twice before making the first application of fertilizer. Some farmers make this application on each side of the row, while others think it is practically as beneficial and more economical to apply to one side only. The prevailing practice is to make the first application of fertilizer when the corn is about 2 feet high and use two-thirds of the total phosphoric acid and potash and one-half of the nitrogen that is to be used on the crop. The fertilizer is distributed evenly over a furrow at least 4 inches from the row of corn. The fertilizer is then covered by cultivating the corn shallow.

The second, or last, application of fertilizer, consisting of one-third of the total phosphoric acid and potash, and one-half of the nitrogen, is made about the time the corn prepares for tasseling. This application is made on the opposite side of the row.

For the first application of fertilizer, materials furnishing nitrogen or ammonia in a slowly available form, such as cotton-seed meal, dried blood, and tankage, should be used. For the second application it is preferable to use nitrogen in a readily available form, like nitrate of soda. The amount of nitrogen necessary to produce a good corn crop will depend upon the rotation. When a heavy crop of crimson clover is turned under as a green manure for corn the nitrogen may be economically omitted from the fertilizer.

Quantity and Composition of Fertilizer Mixtures Suggested for Two Applications to Each Acre of Corn Grown on Various Kinds of Soil.

Fertilizing material.	Quantity suggested.	Fertilizer constituents contained in mixture.		
		Phosphoric acid.	Ammonia.	Potash.
SANDY SOIL—FIRST APPLICATION.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Cotton-seed meal, 1-7.5-1 per cent *a*	175	1.7	13.1	1.7
Acid phosphate, 16 per cent	140	22.4		
Muriate of potash, 50 per cent	54			27.0
Total		24.5	13.1	28.7
SANDY SOIL—SECOND APPLICATION.				
Acid phosphate, 16 per cent	75	12.0		
Nitrate of soda, 18 per cent	75		13.5	
Muriate of potash, 50 per cent	24			12.0
Total		12.0	13.5	12.0
Total, first and second applications		36.1	26.6	40.7
SANDY LOAM SOIL—FIRST APPLICATION.				
Acid phosphate, 16 per cent	125	20.0		
Cotton-seed meal, 1-7.5-1 per cent *a*	150	1.5	11.2	1.5
Muriate of potash, 50 per cent	43			21.5
Total		21.5	11.2	23.0
SANDY LOAM SOIL—SECOND APPLICATION.				
Acid phosphate, 16 per cent	75	12.0		
Nitrate of soda, 18 per cent	60		10.8	
Muriate of potash, 50 per cent	24			12.0
Total		12.0	10.8	12.0
Total, first and second applications		33.5	22.0	35.0
GRAY LOAM SOIL—FIRST APPLICATION.				
Acid phosphate, 16 per cent	120	19.2		
Cotton-seed meal, 1-7.5-1 per cent *a*	120	1.2	9.0	1.2
Muriate of potash, 50 per cent	30			15.0
Total		20.4	9.0	16.2
GRAY LOAM SOIL—SECOND APPLICATION.				
Nitrate of soda, 18 per cent	50		9.0	
Acid phosphate, 16 per cent	60	9.6		
Muriate of potash, 50 per cent	16			8.0
Total		9.6	9.0	8.0
Total, first and second applications		30.0	18.0	24.2
RED CLAY SOIL—FIRST APPLICATION.				
Acid phosphate, 16 per cent	155	24.8		
Cotton-seed meal, 1-7.5-1 per cent *a*	110	1.1	8.2	1.1
Muriate of potash, 50 per cent	32			16.0
Total		25.9	8.2	17.1
RED CLAY SOIL—SECOND APPLICATION.				
Nitrate of soda, 18 per cent	45		8.1	
Total, first and second applications		25.9	16.3	17.1

a Equals 1 per cent of phosphoric acid, 7.5 per cent of ammonia, and 1 per cent of potash.

Quantity and Composition of Fertilizer Mixtures Suggested for Fall and Spring Applications to Each Acre of Oats Grown on Various Kinds of Soil.

Fertilizing material.	Quantity suggested.	Fertilizer constituents contained in mixture.		
		Phosphoric acid.	Ammonia.	Potash.
SANDY SOIL—FALL APPLICATION.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Acid phosphate, 16 per cent	225	36.0		
Muriate of potash, 50 per cent	60			30.0
Total		36.0		30.0
SANDY SOIL—SPRING APPLICATION.				
Cotton-seed meal, 7.5 per cent	200		15.0	
Nitrate of soda, 18 per cent	50		9.0	
Total			24.0	
Total, fall and spring applications		36.0	24.0	30.0
SANDY LOAM SOIL—FALL APPLICATION.				
Acid phosphate, 16 per cent	190	30.4		
Muriate of potash, 50 per cent	50			25.0
Total		30.4		25.0
SANDY LOAM SOIL—SPRING APPLICATION.				
Dried blood, 14 per cent	100		14.0	
Nitrate of soda, 18 per cent	45		8.1	
Total			22.1	
Total, fall and spring applications		30.4	22.1	25.0
GRAY LOAM SOIL—FALL APPLICATION.				
Acid phosphate, 16 per cent	150	24.0		
Muriate of potash, 50 per cent	36			18.0
Total		24.0		18.0
GRAY LOAM SOIL—SPRING APPLICATION.				
Dried blood, 14 per cent	80		11.2	
Nitrate of soda, 18 per cent	50		9.0	
Total			20.2	
Total, fall and spring applications		24.0	20.2	18.0
RED CLAY SOIL—FALL APPLICATION.				
Acid phosphate, 16 per cent	125	20.0		
Muriate of potash, 50 per cent	32			16.0
Total		20.0		16.0
RED CLAY SOIL—SPRING APPLICATION.				
Cotton-seed meal, 7.5 per cent	170		12.8	
Nitrate of soda, 18 per cent	30		5.4	
Total			18.2	
Total, fall and spring applications		20.0	18.2	16.0

Results point conclusively to the fact that cowpeas may be made to take the place of cottonseed meal in a fertilizer for corn and there has been very little difference in the yields of corn receiving an application of nitrogen and phosphorus, whether these two elements were supplied by cowpeas and acid phosphate, animal manures and acid phosphate, cottonseed meal and acid phosphate, or raw ground bone furnishing the same quantities of the two elements. Crops like oats, wheat, and rye, growing in winter and early spring, require relatively more nitrogen than phosphorus since nitrification in the soil is not taking place actively at these seasons.

Oats.—There are two methods of fertilizing oats applicable to different conditions. The first method is suited to all soils, while the second must vary with the farming conditions and the soil. The first method consists of applying phosphoric acid and potash to fall oats at the time of seeding.

Tobacco.—As a fertilizer for tobacco farmyard manure occupies a leading position, both on account of its comparative cheapness and its great effectiveness; a position which would seem to justify the giving of special attention to the production and care of manure.

When manure is not obtainable chemical fertilizers may be used with excellent temporary effect, but with a reduction of net profit as compared with that which it is possible to obtain by the use of manure.

At the present stage it appears that the greatest total yield as well as the greatest net profit has been produced by a fertilizer containing nitrogen, phosphorus and potassium in approximately the same ratio to each other in which they are found in farmyard manure, although the cost of such a fertilizer is enormously increased by reason of the large quantity of nitrogen required. Whether it may be possible to reduce the amount of nitrogen in the fertilizer, through the growing of clover or other leguminous crops in rotation with tobacco, remains to be seen.

As a carrier of nitrogen sodium nitrate appears to be much more effective for tobacco than tankage, but tankage is the material almost universally employed for this purpose in the compounding of ready mixed fertilizers. As the nitrogen in these fertilizers costs the farmer as much or more than that in sodium nitrate it would seem to be wise to purchase and use the more effective material.

In Connecticut Russian or hairy vetch has been found to be an excellent cover crop for tobacco. This legume was found to be resistant to cold, heat, and drought; occupied the ground during the fall, winter, and spring; decayed rapidly when turned under; and enriched the soil by its ability to "fix" or utilize atmospheric nitrogen when properly inoculated—that is, when the bacteria were present to cause the formation of root nodules. As a preventive of wind and water erosion the matlike growth of hairy vetch gives it great value; as a source of humus its extensive root system and the readily decomposable nature of the whole plant are peculiar advantages, and it seems to possess in addition, on land successively cropped to tobacco, a green-manuring value considerably above its purely chemical content and the physical improvement of the soil resulting from its use. The full nature and amount of these benefits will require more extensive tests.

Potatoes.—Scarcely any plant is more affected by a deficiency of potash in the soil than the potato. It is a great feeder on potash. From experiments recently made in Germany the conclusion is drawn that muriate of potash of itself does not lessen the starch content of the potato, but that an impurity, magnesium chloride, which is often present, produces decidedly injurious results. Even if this impurity were absent, practically the same results would be expected, for the muriate of potash would combine with magnesia, which is always present in the soil, and form the injurious magnesium chloride. With sulphate of potash this would not be the case. In order to get potatoes of the best quality, they must be grown on rich soil well supplied with moisture, and every effort should be made to prolong the lives of the plants.

On soils which do not need potash, a mixture of equal parts of cottonseed meal and acid phosphate gives good results. The quantity applied is from 300 to 800 pounds per acre. The mixture is improved by replacing a part of the cotton seed meal with one-half as much of nitrate of soda.

Top dressings of nitrate of soda are also sometimes made on potatoes. Soils on which potatoes are grown very often will sooner or later need potash, as the potato plant requires a good deal of potash. For soils deficient in potash a potato fertilizer contains from 3 to 4 per cent nitrogen, 6 to 8 per cent phosphoric acid, and 4 to 8 per cent potash. The following formula is recommended by the Georgia Experimental Station for Irish potatoes:

Acid phosphate, 14 per cent.............	1,000 pounds.
Muriate of potash......................	250 pounds.
Nitrate of soda..........................	420 pounds.

This fertilizer would contain about 8.4 per cent phosphoric acid, 4.0 per cent nitrogen, and 7.5 per cent potash. It is applied at the rate of 350 to 700 pounds per acre.

Authorities Consulted.—F. Bs. 48, 286, 398; Bu. Plt. Ind. B. 404; Bu. Soils B. 67; Ark. E. S. B. 46; Colo. Ag. Col. B. 115; Fla. E. S. B. 50; Univ. Ill. B. 115; Purdue Univ. Bs. 18, 92; Md. E. S. Bs. 126, 151; Mass. Ag. Col. B. 18; Univ. Minn. Bs. 94, 102; Miss. E. S. B. 99; Cornell Univ. B. 241; N. Y. E. S. B. 205, 206; O. E. S. Bs. 54, 141, 161, 172, 206; Ore. E. S. B. 79; Pa. Col. B. 49; Univ. Tenn. Bs. 1, 3; Tex. E. S. Bs. 84, 85, 112, 115; W. Va. Univ. B. 101; Bu. Plt. Ind. Bs. 51, 134; Bu. Soils B. 62; Mass. Col. B. 10; O. E. S. Bs. 59, 125, 182.

Green Manuring.—Green manuring, or the plowing under of green crops is one of the oldest methods used to maintain or to increase the productivity of the soil. The effect of green manuring varies according to the original character of the soil. In general sandy or gravelly soils are made darker in color and become more retentive of moisture. Clayey soils are made more porous and friable, so that they are less likely to puddle or bake, and are less subject to washing. Loamy soils are less noticeably affected than others.

The most important object achieved by green manuring is the addition of humus to the soil. Other things being equal, the best green-manure crop is that which furnishes the largest amount of material which will readily decay in the soil and thus form humus. There are, however, additional ways in which such a crop may be beneficial. Deep-rooted plants are decidedly preferable to shallow-rooted ones because they penetrate into the subsoil. In this way air and water find entrance, especially after the roots decay. Thus in a way every deep-rooted plant is a subsoiler. It is also supposed that such plants, especially when plowed under, tend to enrich the surface soil with potash and phosphorus from the subsoil, thus bringing these substances within the reach of shallow-rooted plants.

Leguminous plants are more valuable for green manuring than others because they not only provide humus but also have the ability to use the nitrogen of the air, which upon decaying they add to the soil. For this reason green-manure crops should always be legumes if such are adapted to the particular locality where needed and can be sown at the time desired.

Use of Green Manures.—Green manuring as a definite farm practice can be recommended only under certain conditions. It is profitable in upbuilding poor soils and in improving the physical condition of sandy, clayey, and adobe soils. In orchards green manures may, as a rule, be used very advantageously, as they do not interfere with the fruit crops. Green manuring can not be recommended on good soils, except at long intervals when there is reason to believe that there is need either of more humus or more nitrogen. Where red clover or alfalfa can be used in rotation the need of a special green-manure crop is seldom felt. The reason lies in the fact that about one-third of the weight of the clover plant and nearly one-half of that of alfalfa is in the root, so that these plants virtually produce a green-manure crop under the ground in addition to the regular crop of hay. Sweet clover is another plant of this class and of wide adaptation as to soil and climate, but unfortunately the hay is not readily eaten by cattle, so that it is used in limited sections only.

A serious objection to a green-manure crop lies in the fact that it must ordinarily take the place of a regular crop, so that the income from the land is lost for the season. The value of the practice in any particular case must be measured by the results secured in the subsequent crop. Frequently it will happen that as good or nearly as good results can be obtained by the use of commercial fertilizers; in such cases it is often best to use them, thus retaining the use of the land for the season. Sooner or later, however, the humus of the soil becomes depleted and must be replaced. Where clover or some similar large-rooted crop can not be used in rotation, recourse must be had either to green manuring or to the application of barnyard manure.

The use of green manures in semiarid regions is as a rule impracticable, as with insufficient moisture vegetable matter decays very slowly. The soil is thus filled with air spaces and loses much more water by evaporation.

The Principal Leguminous Crops.—There are in the United States 15 leguminous field crops that are more or less extensively grown. In the approximate order of their importance they are as follows: Red clover, alfalfa, cowpeas, alsike clover, crimson clover, white clover, Canada peas, soy beans, peanuts, vetch, velvet beans, Japan clover, and bur clover. A few more are cultivated to a less extent, as sweet clover, beggarweed, grass peas, fenugreek, and horse beans. Many others have been tested in an experimental way, but as yet are not grown as crops.

From an agricultural point of view legumes may be classified into three groups: (1) Summer annuals, including cowpeas, soy beans, peanuts, beans, velvet beans, and in the North common vetch and Canada peas; (2) Winter annuals, comprising crimson clover, bur clover, hairy vetch, and in the South common vetch and Canada peas; (3) Biennials or perennials, embracing red clover, white clover, alsike clover, alfalfa, and sweet clover.

Each of these crops can be grown advantageously only in a more or less definitely limited region. For the particular purpose in view, it rarely happens that a choice of two or more equally valuable legumes is offered. Usually one is so much superior to any other available that substitution is practically out of the question. In a few cases, however, the use of one legume in place of another is practicable. Thus cowpeas and soy beans are agriculturally much alike and are adapted to nearly the same regions. In a like manner crimson clover, bur clover, and the vetches over a large area may be used one in place of another. In some sections the culture of red clover is no longer profitable, principally owing to diseases. Alsike clover has been used to some extent as a substitute, but the yield is ordinarily much less. There is also an increasing use of alfalfa in place of red clover, but with alfalfa the best practice is to keep the fields in this crop three years or longer.

How Legumes Get Nitrogen From the Air.—It was known even in ancient times that much larger crops of various kinds could be produced on land that had been in clover or lupines the previous season.

In modern agriculture the value of legumes is quite generally appreciated, as seen in the common practice of growing clover or some other legume in rotation at frequent intervals. The reason why legumes have a beneficial effect was discovered by Hellriegel and Wilfarth in 1886, though many accurate experiments had long before proved the fact.

An examination of the roots of leguminous plants will reveal on many of them nodules or tubercles; sometimes very few, sometimes very many. These vary in size and shape according to the kind of plant. Thus, on red clover they are more or less round, and quite small; on the cowpea they are also round and nearly smooth, but much larger; on the velvet bean they may even reach the size of a pigeon egg; on the vetches they are irregular, both in shape and size. The differences in the tubercles are such that in many cases it is possible to determine the plant to which the root belongs.

Hellriegel and others have proved beyond any question that when leguminous plants have these tubercles on the roots they can make use of the free nitrogen of the air; when they do not have these tubercles they are powerless to do this, but must obtain their supply of nitrogen from the soil in the same manner as most other plants. It has further been proved that these tubercles are caused by a certain kind of bacteria, and that it is really by these bacteria that the nitrogen of the air is absorbed so that it can be used by the clover or by other legumes. There is thus a peculiar interrelation established between the leguminous plant and the bacteria. The latter obtain their principal nourishment from the legume, while in turn they provide nitrogen from the air which can be used by the host plant.

Inoculation.—Nearly every legume has its own particular strain of nodule bacteria. For example, that of the clover is different from that of alfalfa, and that of the cowpea distinct from that of the soy bean. In planting a leguminous crop for the first time it will therefore often happen that no tubercles will form on the roots, because the proper kind of bacteria is not present in the soil. These may be supplied by scattering soil from a field where the crop in question has been recently grown, or by using an artificial culture of the proper bacteria. After the field is once thoroughly inoculated there is rarely any difficulty afterwards in getting an abundant supply of root tubercles.

The same strain of bacteria will often inoculate different closely related legumes. Thus alfalfa, bur clover, and sweet clover are tubercled by the same strain; a different strain inoculates most kinds of vetches, as well as the field and garden peas; still another strain is apparently used by red clover, white clover, and alsike clover in common.

There is a marked variation among different legumes, both in the extent to which they are naturally tubercled and in the ease with which different ones may be artificially inoculated. Natural inoculation presupposes the existence of the proper germ in the soil, and this is nearly always present over areas where a particular legume has been generally grown. Thus red clover is practically always naturally inoculated in the northeastern quarter of the United States and cowpeas in the southeastern. Alfalfa is naturally tubercled as a rule in the West, while in the East artificial inoculation is usually necessary.

Artificial inoculation is usually accomplished with ease as regards cowpeas, red clover, vetches, field peas, and most other legumes. Soy beans, however, frequently give negative results. Sweet clover is much more readily inoculated than alfalfa, though both use the same strain of bacteria. In some cases the tubercle germs occur in sufficient abundance on the seeds to provide inoculation. This occurs more particularly on seeds that are tramped out by oxen or which otherwise become covered with dust from the field.

Sources of Soil Nitrogen.—Nitrogen, as purchased in commercial fertilizers, such as nitrate of soda, guano, tankage, and dried blood, is the most expensive manurial substance a farmer has to buy. Its cost in these various forms ranges from 15 to 20 cents a pound. To a very large extent, at least, the purchase of the costly nitrogen ous fertilizers can be avoided by the growing of green-manure crops, especially legumes.

There are two principal ways in which nitrogen is naturally added to the soil. The first and much more important way is by means of legumes. This takes place only when the roots of the leguminous plant bear bacterial nodules or tubercles. The amount of nitrogen that any particular legume can add is directly proportional to the number and size of the tubercles on its roots. Little is known regarding the relative abilities of different legumes to fix atmospheric nitrogen, though they differ widely. It has sometimes been assumed that those are most efficient whose herbage is richest in this substance. This is at least questionable, as these same species may be able to utilize more of the soil nitrogen than others.

The second way in which nitrogen is added to the soil is through the activity of certain soil bacteria. These, especially if provided with decaying vegetable or animal matter, are able to use the nitrogen of the air, forming nitrogen compounds. The amount of the nitrogen thus fixed depends on a number of factors. A supply of decaying material must be available as food for the bacteria, the soil must be well aerated and must not be sour, and there must be lime or other substance in the soil with which the nitrogen can be combined. With these conditions fulfilled the bacteria are most active when the soil is warm—that is, in summer. It is now believed that the principal benefit achieved by summer fallowing is the increase in the amount of nitrogen by soil bacteria. It may here be pointed out that in experiments green-manure crops have yielded the best results when turned under shallow. This result is perhaps due to the fact that the best conditions are thus provided for the activity of the soil bacteria.

Loss of Soil Nitrogen.—It is important to know that under certain conditions nitrogen may escape from the soil as a gas. This result is brought about principally by certain organisms, called denitrifying bacteria, that break up nitrogen compounds and permit the nitrogen to escape, usually in the form of ammonia. Little is yet known of this process, but it is believed to occur under various different conditions. There are probably different bacteria which under different conditions cause these losses. It is known, however, that large loss is likely to occur when there is present abundant decaying matter, high temperature, and lack of air. Such losses occur particularly in rich water-logged lands and in manure heaps. For these reasons it is not good practice to endeavor to obtain a large store of nitrogen in the soil beyond the needs of the crops. For the same reason green-manure crops should not be used on lands that are decidedly wet.

Composition of Green-Manure Crops.—The essential fertilizing substances added to the soil as manures are nitrogen, phosphorus, and potash. The accompanying table gives the amount of these substances in both the tops and roots of several legumes, as shown by a number of analyses of each.

It has been found that all plants vary widely in the relative amount of these materials they contain. The same plant varies when grown on different soils or in different seasons on the same soil. The cause for the variation in nitrogen has been fully explained. The reason for the variation as regards the other substances which are obtained wholly from the soil are obscure. In the accompanying table it will be noted that the variation in legumes as regards phosphorus and potash is nearly as great in any one legume as it is between different legumes. It has been suggested by several writers that certain green-manure crops by feeding heavily on phosphorus and potash make these substances more available to subsequent crops. It is very doubtful whether this is true, but if it is there is little apparent advantage of any one legume over another in this respect.

Fertilizing Materials in 100 Pounds of Dry Substance.

[Compiled from various sources.]

Plant and part.	Nitrogen.	Phosphoric acid.	Potash.	Plant and part.	Nitrogen.	Phosphoric acid.	Potash.
Red clover:	*Pounds.*	*Pounds.*	*Pounds.*	Cowpea—Cont'd.	*Pounds.*	*Pounds.*	*Pounds.*
Tops.........	2.56	0.72	1.40	Tops...........	2.09	.56	3.04
Tops.........	2.07	.38	2.20	Roots..........	1.19	.67	1.94
Tops.........	1.97	.56	1.86	Roots..........	.68	.64	1.16
Tops.........	2.81	.65	3.10	Roots..........	1.46	.16	.77
Roots........	2.74	.84	.82	Roots..........	1.40	.73	.76
Alfalfa:				Soy Bean:			
Tops.........	2.42	.58	1.42	Tops...........	2.06	.80	1.20
Tops.........	2.30	.53	1.46	Tops...........	2.32	.67	1.08
Tops.........	2.19	.51	1.68	Tops...........	2.97	.55	1.98
Roots........	2.04	.43	.48	Tops...........	2.60	.65	2.23
Crimson clover				Tops...........	1.53	.57	1.76
Tops.........	2.38	1.10	1.56	Tops...........	2.01	.65	2.17
Tops.........	2.05	.40	1.31	Tops...........	1.75	.40	1.32
Tops.........	1.95	.36	1.17	Roots..........	.81	.36	.90
Roots........	1.50	.47	1.02	Roots..........	1.22	.32	.24
Cowpea:				Roots..........	1.11	.35	.87
Tops.........	2.32	.51	2.92	Velvet bean......	2.51	.53	3.84
Tops.........	1.81	.65	1.29	Common vetch:			
Tops.........	1.59	.30	1.53	Tops...........	3.53	.74	2.56
Tops.........	1.95	.52	1.47	Tops...........	3.18	.77	3.50
Tops.........	1.75	.45	1.27	Tops...........	2.27	.62	1.97
Tops.........	2.23	.57	2.00	Roots.........	2.19	.79	1.18

Green Manuring Compared with Feeding.—Barnyard manure contains from 75 to 90 per cent of the total fertilizing substance in the feeds used. It is beyond question a better practice from all standpoints to feed a crop, whether leguminous or nonleguminous, and then distribute the manure over the land, than it is to plow under the whole crop. This practice utilizes the whole feed value of the crop. Further, it returns an important part of it to the soil in a highly available form for plant food. Unquestionably this is the very best farm practice in maintaining soil fertility. Were it possible on any farm to feed the entire product to live stock, returning the manure to the soil, the productivity of that farm would be maintained indefinitely. The only depletion that would occur would be the comparatively small amount of potash and phosphorus sold in the live-stock product. The loss of nitrogen would be more than maintained by the activity of the soil bacteria.

It is, of course, well known that other causes than the removal of plant food may reduce the productivity of the soil. Such causes as sour soil, the deleterious effect of one crop upon the succeeding one, and poor tillage may and often do result in poor crops. These causes are, however, largely within the control of the farmer and in no way affect the general statements above made.

The feeding of crops, taken as a whole, is necessarily limited by the total demand for live stock. The total number of live stock required to supply the market demands can furnish but a small proportion of the manure needed. On this account the practical use of barnyard manure is naturally limited to regions where animal husbandry is prominent. Where stock raising is but little developed recourse must be had to other fertilizers. It is primarily in such regions that the use of green manures is necessitated.

Orchard Cover Crops.—The term "cover crops" was originally used to include crops grown for various diverse purposes, such as to prevent soil washing, to hold drifting snow, for keeping the soil warm in winter, and to hasten the ripening of wood. As these crops were used largely in orchards and as they were often legumes, so that they might serve also as green manures, the term cover crop is frequently used to include crops grown in orchards primarily for green manure.

The growing of leguminous crops in orchards is generally considered excellent practice, except in dry regions where irrigation is impracticable. In the citrus orchards of southern California a number of different legumes are used as winter cover crops; among them Canada peas, common vetch, hairy vetch, and fenugreek. Besides these, many others have been tried in an experimental way, such as horse beans, scarlet vetch, black-purple vetch, lupines, sweet clover, and berseem. The two first mentioned are most used at present, and the general opinion is that the practice is decidedly profitable. There is, however, a lack of accurate data on this point. Some orange growers are also using cowpeas as a summer cover crop.

In Delaware and other States of the Atlantic Seaboard, crimson clover is the most common legume used as a cover crop. To a less extent common vetch and hairy vetch are employed. At the Ohio Agricultural Experiment Station it was found that apple trees grew more rapidly and yielded larger crops when the orchard was kept in grass. After each mowing the straw was used as a mulch about the trees. Where the trees were cultivated in a circle of 3 or 4 feet about the base, the results were distinctly inferior. Clean summer culture with a winter cover crop gave results intermediate between the other two.

It is probable that the best results in different portions of the country will be obtained by different methods. There is much need of determining accurately the results of different treatments as shown both by the growth of the trees and the crop produced.

Crops to Follow Green Manures.—The plowing under of large quantities of green herbage, especially when this is done during the summer, often brings about the formation of considerable acid, or, in other words, makes the soil sour. This condition may be corrected by the use of lime, which should be applied at the rate of a ton to a ton and a half to the acre. Some farmers claim to get much better results by applying the lime before plowing under the crop. In any case, it is advisable to let the green manure after being plowed under decay a month or more before planting the succeeding crop.

The full results of a green manure are obtained only after it is completely decayed and changed into a soluble form. This requires considerable time, so that the beneficial results are often shown for two or more seasons. Generally speaking, cultivated crops are the best to follow green manures. The tillage of such crops hastens the decay of the vegetable matter and, by aerating the soil, favors additional nitrogen fixation by the soil bacteria. Corn, cotton, potatoes, and tobacco, on most soils, derive great benefit when following green manures. Rye and oats are likewise good crops to use in this way. Wheat and barley give varying results, often very favorable, but not infrequently there is no increase or even a loss. This is especially true the first season following a green-manure crop.

The Choice of a Green-Manure Crop.—Whenever a green-manure crop is to be used, preference should be given to a legume if it is available, because such a crop will add materially to the nitrogen content of the soil. Where there is a choice between two or more legumes, the question arises as to which is to be preferred. Among the important points that determine the value of a leguminous crop are (1) its value as forage, both in quantity and quality, either as hay or pasture; (2) its ability to supply additional nitrogen. Other points that deserve consideration are the cost of the seed, the ease of plowing under the crop, the deep-rootedness of the plants, and their ability to choke out weeds. On lands of fair quality the largest profit is usually obtained by using the crop as fodder. This may be done by harvesting it for hay, leaving only the stubble to be added to the soil, or by pasturing the crop, by which means the most of it is returned to enrich the land.

Where the whole crop is plowed under, the effect on the subsequent crops is determined mainly by three factors, namely, the amount of humus formed, which is directly measured by the tonnage of the crop; the physical changes brought about in the soil, and the quantity of nitrogen taken from the air and added to the soil. It is generally believed that the addition of nitrogen is the most important of these factors. While different legumes are known to vary in their respective abilities to absorb atmospheric nitrogen, there is much yet to be learned on the subject. If the benefit of different legumes is proportional to the amount of nitrogen each adds to the soil, then their relative values can be determined in advance. Thus far the value of different green manures has been determined wholly or mainly by the influence they have on the succeeding crop or crops.

THE PRINCIPAL GREEN-MANURE CROPS.

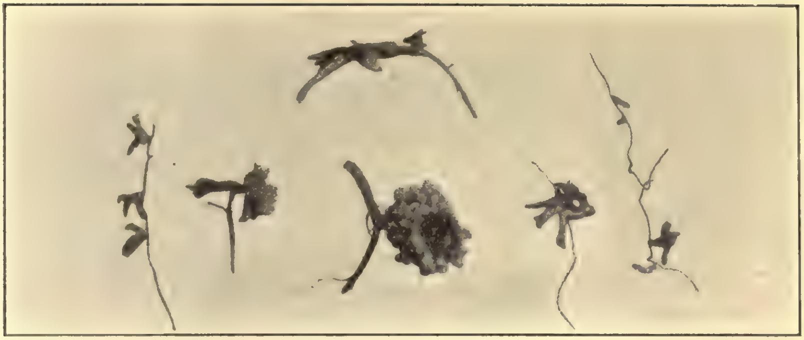
Red Clover.—This is the most common legume used in rotations in the Northern States. It is usually grown with timothy, following wheat or other small grains. As a general rule the timothy seed is sown in the fall with the grain, and the clover is sown the following spring. While the beneficial effect of plowing under red clover or red clover sod is well known, there has been but little work done at the agricultural experiment stations to determine accurately the amount of benefit secured. Results obtained at the Illinois Agricultural Experiment Station gave an average yield of 35 7/10 bushels of corn where this crop was grown year after year on the same land. In rotations, the average yield was 55 1/10 bushels for the first crop after clover and 48 3/5 bushels for the second crop after clover.

The Cowpea.—This is used more than any other crop as a soil renovator in the South. Its use is rapidly increasing, but is yet far from general. During the past few years the high price of the seed has tended to discourage more extensive growing. Recent progress in the harvesting of cowpea seed by machinery will doubtless materially reduce its cost. The seed is at present almost entirely picked by hand. The cowpea is characterized by remarkable ability to grow in poor soils and to cover the ground so densely as to choke out most weeds. It usually bears an abundance of tubercles on its roots, whether the soil has been inoculated or not, although in new localities where the cowpea has not been previously grown the tubercles may be absent. In such cases inoculation is necessary, for it must always be remembered that it is through the tubercles on the roots that the beneficial effects of the cowpea or other legume largely depend.

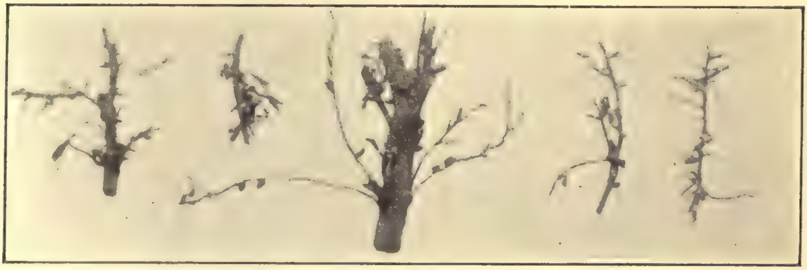
Cowpeas are very commonly planted between rows of corn at the time of the last cultivation, or they are broadcasted upon the stubble of small grains. Cowpeas, however, like other crops, respond markedly to cultivation and there is a growing tendency to plant them upon well prepared soil. This practice results in a great increase of the crop, whether grown for hay or for seed.

More numerous experiments have been conducted in this country to determine the effects of cowpeas used as a green manure than have been devoted to all other leguminous crops combined. Almost without exception these experiments have indicated a very beneficial effect upon the succeeding crop. The benefit often lasts two or three years. These good results follow on practically all succeeding crops, whether cotton, corn, sorghum, or small grains. Except on the poorest soils careful experiments show that it is decidedly more profitable to use the cowpea crop as hay or pasture and then plow under the stubble than it is to plow under the whole crop. While plowing under the whole crop produces as a rule a greater effect, it is not enough greater to equal the value of the cowpea crop as feed.

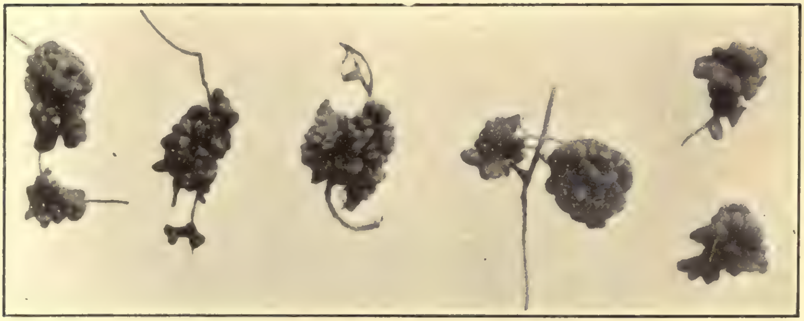
Soy Beans.—These are adapted to a much wider range of climate than cowpeas, being grown successfully even in Ontario and Massachusetts. As a forage crop soy beans have some points of superiority over cowpeas, the hay being somewhat easier to cure and



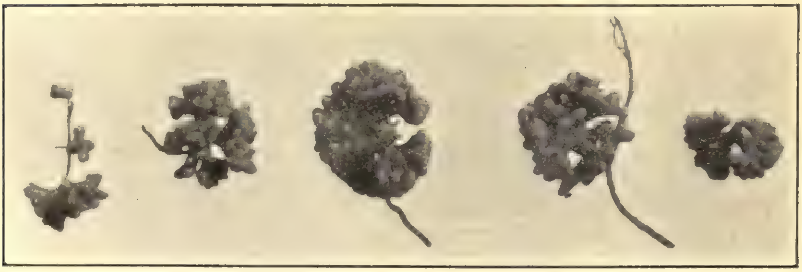
Alfalfa Nodules, Year Book, 1908



Red Clover Nodules, Year Book, 1910



Garden Pea Nodules, Year Book, 1910



Vetch Nodules, Year Book, 1910

richer in protein. The seed is also cheaper than that of cowpeas, usually costing only two-thirds as much. This is principally due to the fact that the seed can readily be harvested by machinery. It also has an advantage in that the seeds are but little affected by weevils. On these accounts soy beans are preferred by an increasing number of farmers in the South. Soy beans, however, are not able to compete with weeds as successfully as cowpeas, and on this account the best results are obtained by planting in rows, so that they may be cultivated. There is considerable difficulty experienced at first in obtaining tubercles on the roots of soy beans, but when once these have appeared in a particular piece of ground there is no further trouble. Apparently, soy beans have a greater power than cowpeas to absorb atmospheric nitrogen through their roots.

In an investigation conducted at the Michigan Agricultural Experiment Station it was found that inoculated soy beans were enabled to add per acre 37.57 pounds of nitrogen provided from the air. At the Arkansas Agricultural Experiment Station soy beans used as green manure gave nearly as good results as cowpeas, as determined by subsequent crops of wheat, oats, cotton, and corn. With cotton, the soy bean vines produced a larger yield of cotton than cowpea vines, but the cowpea stubble gave a larger yield than the soy bean stubble. With corn, cowpea stubble and soy bean stubble yielded the same results, while soy bean vines gave better results than the cowpea vines. With oats, the results were slightly in favor of the cowpeas. It is not improbable that the variation in results may be largely due to variation in the amounts of atmospheric nitrogen added by the legumes to the different plats. Those that were most heavily tubercled would add the most nitrogen.

Velvet beans have been tested in comparison with cowpeas at the Arkansas and Alabama agricultural experiment stations. The velvet bean is somewhat objectionable on account of the very viny habit of the plant, which renders it difficult to plow under. In orchards velvet beans have been found objectionable on account of their tendency to climb the trees. At the Arkansas Agricultural Experiment Station velvet beans gave better results on a subsequent crop of cotton than either soy beans or cowpeas, the velvet bean plat yielding 1,550 pounds of seed cotton, against 1,448 pounds for the soy beans and 1,335 pounds for the cowpeas. With wheat, velvet bean stubble gave better results than either cowpea stubble or soy bean stubble, though the difference was very slight. It is noteworthy also that velvet bean stubble gave much better results on the succeeding crop of wheat than where the whole crop of velvet bean vines was plowed under, and the same was true in regard to both cowpeas and soy beans. In all cases, however, there was a marked increase of crop, due to the influence of the legumes.

At the Alabama Agricultural Experiment Station the following yields of sorghum hay were obtained: After fallow, 3,792 pounds per acre; after cowpeas plowed under, 7,008 pounds; after velvet beans plowed under, 7,064 pounds. Here the legumes nearly doubled the yield of the sorghum hay, the velvet beans being slightly better than the cowpeas. In a similar experiment where only the stubble was plowed under, the velvet beans in two cases showed a slight superiority over the cowpeas. Where corn was used to determine the effect of the legume, cowpeas gave slightly better results than similar plats with velvet beans, whether the stubble or the whole vines were plowed under. Where cotton was used as a measuring crop, the results were in favor of the cowpeas. The cowpea plat produced 1,533 pounds, the velvet been plat 1,373 pounds, and the check plat 837 pounds, respectively, of seed cotton. Comparison of all the results obtained showed that there is practically no difference as regards fertilizing value between velvet beans and cowpeas.

Crimson Clover.—This is much grown as a green manure and forage crop along the Atlantic seaboard from New Jersey southward and to a less extent in the Gulf States. It has been grown to a slight extent in various other States, but owing to the frequency with which it winterkills it has not been established as an important crop. It is most largely grown in the Middle Atlantic States, and its use has greatly increased in late years.

Crimson clover gives the best results when sown in late summer, preferably from July 15 to September 1. It is most commonly planted in corn or following a small grain crop. In the latter case the land should be plowed and put in good condition before seeding. Considerable difficulty is often experienced in obtaining a stand of crimson clover. Indeed, it is a common saying that it must be sown between showers in order to be assured of a stand. It is important always to use fresh seed, as the germinating power deteriorates rapidly. Ordinarily 12 to 15 pounds per acre is used, but good results have been obtained with smaller quantities. In some cases the failure to obtain a stand has been attributed to the lack of inoculation. In any event it is always desirable to inoculate the seed or the soil before planting on land for the first time. Even if a stand is only obtained two times out of three crimson clover is still a very profitable crop to grow.

A number of careful experiments with crimson clover have been conducted both by the Delaware and Maryland agricultural experiment stations. At the Maryland Agricultural Experiment Station it was found that potatoes following crimson clover plowed under yielded 72 3/10 bushels per acre, while on an adjoining plat where no crimson clover had been sown the yield was 52 4/5 bushels. On the same plats the following year the yields were, respectively, 102 1/5 bushels and 67 4/5 bushels—an increase of 27 bushels per acre, or more than 45 per cent, due to the effect of the crimson clover. In a similar experiment with corn a yield of 46 bushels per acre was obtained following crimson clover, as against 39 3/10 bushels where no clover had been sown. At the Delaware Agricultural Experiment Station sweet potatoes yielded an increase of about 18 bushels per acre, due to the effect of crimson clover, a gain equal to that produced on adjoining plats by the addition of 160 pounds of nitrate of soda.

In addition to its value as a green manure, crimson clover is also important as a cover crop, tending to prevent the leaching and washing of soils, especially on hilly land. As a cover crop it is much employed in orchards. For the improvement of poor lands in the Middle Atlantic region there is no better plan than to use crimson clover as a winter crop and cowpeas as a summer crop.

Sweet Clover.—This is a biennial plant, somewhat weedy in character, which grows readily on almost all soils. It produces an enormous root, and the tops often grow to a height of 4 or 5 feet. Owing to the bitter character of the herbage it is not much liked by stock, which have to learn to eat it. In a few sections of the country it is grown as a hay crop. As a crop, sweet clover is most largely grown in Alabama and Mississippi, where it is utilized both for hay and for its improvement of the soil. It is considered at least equal to red clover for the latter purpose.

Owing to the ability of sweet clover to grow in the poorest of soils, it will probably be found of high value in increasing their fertility. The seed should be planted very early in the spring, using about three-fourths of a bushel of the seed in the pod, the common form in which it is found on the market. The greatest benefit will be found in plowing it under the second season, before it blooms.

In an experiment conducted at a German agricultural experiment station sweet clover was sown in May with rye, seeding at the rate of 21 pounds of hulled seed per acre. The following summer the sweet clover was plowed under and followed with oats. The yield was 1,099 pounds per acre on plats where no sweet clover had been sown and 1,645 pounds per acre where sweet clover had been used.

Canada Peas.—These are grown mainly in the northernmost States and in Canada. As a winter green-manure crop in orchards they have been used considerably of late years in California. Very few accurate experiments have been conducted to determine the effect of Canada peas upon succeeding crops. In one such experiment conducted at the Ontario Agricultural College wheat was grown on three different plats on which peas, rape, and buckwheat, respectively, had been plowed under. The yield of wheat following Canada peas was 36 1/10 bushels; following rape, 30 2/5 bushels; following buckwheat 26 3/5 bushels. There is here a clear gain shown in favor of the Canada peas. The impression prevails among farmers in the Canada pea belt of Michigan that oats following Canada peas yield an increase of from 5 to 10 bushels per acre, but there are no accurate experiments to substantiate this. At the Maine Agricultural Experiment Station oats were sown on some plats following Canada peas and on others following barley. On three out of four plats the yield of oats was larger following barley than following the peas, and the total of all the plats was much in favor of those that had been in barley the previous year. No mention is made as to whether the peas were tubercled or not.

In a series of rotation tests at the South Dakota Agricultural Experiment Station, extending over seven years, the effect of Canada peas on the wheat was to increase slightly the yield of straw without at all increasing the quantity of grain. Practically identical results were obtained on four different plats where peas preceded wheat. The largest increase of straw was obtained where the peas had been pastured off by hogs. No benefit was observed on one plat where the whole pea crop was plowed under.

At the present time Canada peas are perhaps more used than any other legume in the citrus orchards in California. The effect is very satisfactory so far as improving the tilth of the soil and its ability to retain water are concerned. There are no accurate data available, however, as to the effect on the crop of fruit, but it is generally believed to be very favorable.

Vetches.—Two vetches in particular are cultivated in the United States, the common vetch, or tares, and the hairy, or Russian, vetch. The former is much used as a winter crop for hay on the Pacific coast and in the Southern States, being commonly sown with oats, rye, or wheat. It is also extensively grown in the citrus orchards of California as a winter green-manure crop. In the Northern States it is very likely to winterkill.

Hairy vetch is in a general way like common vetch, but decidedly more resistant to cold. It will ordinarily survive the winter in most parts of the United States and in Canada. In fact it is more resistant to cold than any other annual legume grown. On this account it is particularly valuable in the North. In the Connecticut Valley it has received much favor as a winter green-manure and cover crop on tobacco lands. Where the winter temperature is not cool enough to prevent growing, as in California, it has been found that hairy vetch grows much more slowly in cool weather than the common vetch, and the latter is therefore preferred. Hairy vetch, however, grows very rapidly as the weather becomes warm. Vetches are somewhat objectionable where small grains are used in rotation, as they become somewhat weedy in grain fields. Except for this, vetches are a very valuable crop and deserve much more extensive cultivation.

Tangier Pea.—This is a native of Northern Africa and has been tested quite extensively in California during the past few years. The plant in a general way resembles the garden sweet pea. In comparison with other legumes in California, the Tangier pea has given the largest yields per acre. This pea is also characterized by its ability to form a very dense covering on the ground, so as to choke out weeds almost perfectly. Indeed, no other legume tested on weedy land in California at all equals the Tangier pea in this respect. No experiments have yet been conducted to determine the effect of the Tangier pea when used as a green-manure crop, but from the numerous large tubercles found on the roots, there is little doubt that it will prove exceedingly valuable in this respect. The hay is eaten readily by horses, and it is believed that the crop will become important.

Authorities Consulted.—F. Bs. 278, 245; La. E. S. B. 231; Ont. Agr. Dept. Bs. 164, 169; Wash. E. S. B. 32; Spec. B. Mass. Ag. Col.; Univ. Wyo. B. 44; Univ. Ill. B. 94; Del. Col. B. 60; N. C. E. S. B.

77; Ariz. E. S. B. 45; Colo. Ag. Col. Bs. 99, 178, 179; Mass. E. S. B. 50; Calif. Col. B. 7; F. B. 315; Bu. Plt. Ind. Bs. 63, 71, 76; Univ. Minn. B. 34; R. I. Col. B. 147; Mich. Ag. Col. B. 231; Kans. Ag. Col. B. 160; O. E. S. B. 54.

LIMING OF SOILS.

Ruffin is perhaps the most prominent of the earlier writers who called attention to the agricultural use of lime in the United States. As early as 1818, and later, in 1821, articles on the subject were contributed by him to the American Farmer, and in 1832 appeared the first edition of his well-known work on Calcareous manures. He cites many instances showing the benefit derived from calcium carbonate when applied in the form of marl to his own and other Virginia estates.

In certain parts of Pennsylvania and New York lime has long been considered one of the essentials in wheat production. The beneficial effect of liming has been demonstrated in Alabama, Alaska, New Hampshire, Massachusetts, New York, Virginia, Maryland, Pennsylvania, Oregon, Illinois, and other parts of the United States, but, as Roberts states, probably 99 per cent of the arable soil of the United States has never been limed, and indeed many large areas are not in need of it. The work of the experiment stations, stimulated at the outset by that of Rhode Island, has now shown conclusively that soils which respond profitably to liming, either on account of their acid condition or of a deficiency of lime in other respects, are very widely distributed.

Direct Manurial Action of Lime.—Authorities seem to agree that lime is necessary to the plant, and if it be wholly lacking in soils, even though an abundance of all the other essential elements is present, the plant can not develop normally. The plant can not grow if any one of the essential elements of plant food is lacking. As already stated, lime has been found to be especially deficient in soils derived from granite. It is also often true of soils derived from mica-schist, sandstone, and from certain conglomerates, slates, and shales. Fortunately, however, many soils are well provided with lime by nature and it is seldom or never necessary for those who cultivate them to resort to liming. It would be just as irrational to apply lime where it is not needed as to omit it where it is required, and hence arises the necessity of ascertaining the needs of particular soils in this respect.

The method usually resorted to for ascertaining the amount of lime in soils is to treat them with some strong mineral acid (usually hydro-chloric) and determine the amount of lime which is thus dissolved. Some writers state that if only one-half of 1 per cent is thus shown to be present immediate resort to liming is desirable; others set the amount higher, and some seem to prefer to have present as much as 1 per cent. It is possible that a soil may contain considerable quantities of lime thus removable by acid and yet in actual practice show much benefit from liming. As a matter of fact, soils of limestone origin sometimes show benefit from liming because sufficient carbonate of lime is not present in the soil.

This is due to the continual removal of carbonate of lime by crops and by leaching. Often some carbonate remains, but it is too much inclosed by other materials to be sufficiently active to prevent acidity and to insure the proper changes in the organic matter.

The fact that beets of all kinds make a ready response to liming on soils which are deficient in carbonate of lime may be utilized as the basis for a practical and reliable method of testing the lime requirements of the soil. For this purpose lay out two plats of land, each about 12 by 30 feet, manure each of the plats with like amounts of a fertilizer containing potash, phosphoric acid, and nitrogen, and apply lime to one of the plats at the rate of from 1 to 2½ tons per acre (40 pounds per plat would be approximately 2½ tons per acre). A comparison of the growth and yields on the two plats will furnish a safe means of judging whether the soil will respond profitably to applications of lime. If the crop is helped but slightly by liming, most varieties of plants will not be in immediate need of lime. If the crop is greatly helped or is increased several times, it is likely that the soil is too much in need of lime to make complete success with most varieties of plants possible.

Chemical Action of Lime on Soils.—Lime is said to take the place of potash in certain chemical compounds which exist in soils, thus liberating the potash and placing it at the disposal of plants. In this particular, gypsum (land plaster or calcium sulphate) is believed to act more energetically than carbonate of lime, air-slaked or water-slaked (hydrated) lime.

When soluble phosphates are applied to soils deficient in lime and magnesia the phosphoric acid combines with the iron and alumina of the soil to form compounds which are not readily utilized by plants. If, however, the soil is fairly well supplied with lime and magnesia this transformation is retarded, so that the plant is afforded an opportunity to utilize much of the phosphoric acid before it becomes unassimilable. If a soil containing a certain inert phosphate of iron is heavily limed, it is believed that this phosphate will be changed into a form which the plant can utilize. Lime may therefore not only aid in keeping recent applications of phosphoric acid in assimilable condition for a long time, but it may, if applied in sufficient quantity, help to unlock stores of phosphoric acid, in certain soils, which plants would otherwise be unable to use.

Hilgard has abundantly demonstrated the great value of gypsum (land plaster) in renovating alkali soils in the arid portions of the United States. Wherever too much sodium carbonate (black alkali) is the cause of the unproductive condition of the soil the gypsum reacts with it, producing sodium sulphate and carbonate of lime, whereby the alkalinity may be sufficiently reduced to render possible the profitable production of crops. In case protosulphate of iron and certain other poisonous compounds are present in soils, liming so changes them as to render them harmless to plants.

When the remains of plants undergo decay upon soils deficient in carbonates of lime and magnesia, acid or sour humus is liable to be produced, which is supposed to be particularly noxious to most agricultural plants, though apparently not detrimental to the growth of the cranberry, watermelon, rhododendron, azalea, and a few other herbaceous plants, trees, and shrubs. Such conditions are liable to occur even in upland and naturally well-drained soils. Liming is in all such cases an effectual and probably the most economical remedy.

Physical Effects of Liming.—Many clay soils when wet by rains are not porous enough to allow the water to pass through them with sufficient rapidity, in consequence of which they become waterlogged and the air which is necessary for the healthful development of plant roots within the soil is excluded. In times of drought, also, such soils cake readily, thus becoming more difficult to till and less adapted physically to the growth of plants. Liming is an effective preventive or remedy for all of these unfavorable conditions. Upon certain loamy soils containing considerable clay, liming often renders the surface more friable and less liable to form a crust upon drying.

The improvement of drainage brought about by liming is one of the most effective means of preventing surface washing. When heavy rains occur on limed soils the water sinks into the soil instead of rushing over the surface, carrying the fine soil particles with it and thus producing galls and washes. Soils which are composed of siliceous sand are frequently benefited by being rendered more compact by liming. On such soils pulverized limestone is preferable to ground burnt lime, hydrated lime, or even air-slaked lime, owing to the more powerful action of the latter, and the best material to employ where it is obtainable is a clay marl containing a fair amount of carbonate of lime. The clay, as well as the lime, tends to materially improve the physical condition of the soil. It should also be the aim to increase the amount of organic matter in such soils by the use of muck and stable manures, or by the occasional plowing under of a green crop or of sward.

Effect of Lime on the Action of Microscopic Organisms in the Soil.—Many important changes are produced in the soil by organisms so small that they can only be observed by the aid of the most powerful microscopes. Some of the changes of this character in which lime plays an important part are the following:

(1) The change of ammonia and of nitrogen in organic matter, such as blood, meat, fish, tankage, plants, etc., into nitrates, the form in which it is chiefly assimilated by most cultivated plants. This is known as the process of nitrification and is promoted by the presence of lime in soils.

(2) The decomposition of organic matter in muck and other soils. In this process the production of carbonic acid is much accelerated by the use of lime. This carbonic acid in turn so acts upon the inert plant food of the soil as to make it more quickly available to plants. The indirect result, therefore, is to help the plant to draw more potash, phosphoric acid, etc., from the soil than would otherwise be possible.

(3) The utilization of atmospheric nitrogen by certain of the leguminous plants (notably the clovers), particularly upon sour soils, is facilitated by the application of lime.

Liming Sometimes Injurious.—Excessive amounts of lime, especially on light soils, may have an injurious action. This is particularly true of freshly slaked lime and of ground limestone upon light sandy soils, which are inclined to be dry and which contain only small amounts of organic matter. It hastens unduly the decomposition of organic matter, and thus renders the soil more open and less retentive of fertilizers and moisture than before. If either ground burned lime or slaked lime must be used upon such soils it should be applied in small amounts and at not too frequent intervals. As stated heretofore, clay marls are much better adapted than other forms of lime for the improvement of such soils. In lieu of such marl either wood ashes or lime which has been exposed to the action of the air for a long time is usually preferable to lime which has been recently prepared.

Before the advent of complete fertilizers it was a common adage that liming makes rich fathers and poor sons. If lime is used alone it serves to liberate potash, nitrogen, and sometimes phosphoric acid, and often the extra drain of increased crops on the soil leaves it finally in a worse condition than at the outset. In other cases the soil reverts after many years to its former state of unproductiveness, without appreciable injury. Continued success with lime can only be assured by the use of other essential manurial substances in connection with it. Few, if any, cases are on record where soils originally in need of lime have failed to continue to give good results from liming when care has been taken to maintain a proper supply of the other essential constituents and where lime has been applied in moderate amounts.

There are impure limestones which after burning yield material that will harden like cement and which on this account may have an injurious action upon the soil. If such limestone is pulverized without burning it is capable of yielding good results. Dolomitic (magnesian) limestone contains widely varying percentages of magnesia and lime. Such stone, if containing high percentages of magnesia, may sometimes prove objectionable if used exclusively.

Should injury arise from the accumulation of an undue amount of magnesia, this can be overcome by an application of ordinary lime. Rather than to use magnesian lime successively upon the same land it would be preferable to replace it frequently with lime containing little or no magnesia. Notwithstanding what has been said, the presence of some magnesia in lime is by no means objectionable, and it may, on certain soils, prove positively beneficial.

Plants Benefited by Liming.—The following are some of the plants which, in experiments on acid soil at the Rhode Island Agricultural Experiment Station, have shown marked benefit from the use of lime: Spinach, lettuce (all kinds), beets (all kinds), okra (gumbo), salsify (vegetable oyster), celery, onion, parsnip, cauliflower, cucumber, eggplant, cantaloupe, asparagus, kohl-rabi, cabbage, dandelion, Swedish turnip, pepper, peanut, English or flat turnip, upland cress (pepper grass), martynia, rhubarb, common pea, pumpkin, summer squash (scalloped), golden wax bean, red valentine bean, horticultural pole bean, bush Lima bean, lentil, Hubbard squash, saltbush, hemp, tobacco, sorghum, alfalfa, clover (red, white, crimson, and alsike), barley, emmer, wheat, oats, timothy, Kentucky bluegrass, Canada pea, Cuthbert raspberry, gooseberry, currant (White Dutch), orange, quince, cherry, Burbank Japan plum, American linden, American elm, sweet alyssum, mignonette, nasturtium, balsam, pansy, poppy, and sweet pea. The crops were not only greater in many cases, but they were ready to be marketed much earlier where the soil had been limed. Tobacco not only made a better growth when limed, but the ash was much lighter in color.

So far as concerns potatoes, the total crop is frequently not materially increased by liming, but the percentage of tubers of merchantable size is usually increased if the soil is quite acid, thus adding greatly to the total value of the crop. On account of the fact that liming increases the injury caused by potato scab care must be taken to treat the seed tubers with corrosive sublimate solution, formalin, or other fungicide capable of destroying most of the germs of the disease before the tubers are planted. Furthermore, lime should be applied after the removal of the potato crop, except in case of land that has not been previously limed.

Plants But Little Benefited by Liming.—There are many plants which, when supplied with sufficient potash, phosphoric acid, and nitrogen in immediately assimilable combinations, such as nitrate of soda and nitrate of potash, show but little if any benefit from liming even upon quite acid soils. Among these plants are the following: Indian corn, spurry, rye, carrot, chicory, Rhode Island bent, and redtop. Upon a very acid soil some of these plants might show greater benefit from liming provided the nitrogen were supplied in sulphate of ammonia, blood, tankage, fish, cotton-seed meal, plant roots, or other nitrogenous substances, the decomposition and nitrification of which would be hastened by the presence of lime.

Plants Usually or Frequently Injured by Liming.—Among the plants which have shown slight injury from liming under certain conditions and which may under other circumstances be helped by it are the following: Cotton, tomato, cowpea, zinnia, phlox (Drummondi), Concord grape, peach, apple, and pear. The plants that have quite persistently shown marked injury from liming are: Lupine, common sorrel, radish, velvet bean, flax, castor bean, blackberry, black-cap raspberry, cranberry, Norway spruce, and American white birch. Extensive European tests have also shown that lupine is injured by liming. Lime, though directly injurious to common sheep sorrel, aids in ridding land of it more by virtue of encouraging other plants than on account of the direct injury which it causes. It is claimed that the chestnut, azalea, and rhododendron are injured by lime, though they have not yet been tested at the Rhode Island Station.

INFLUENCE OF LIME UPON SOME PLANT DISEASES.

Potato Scab.—It has been shown that carbonate of lime and such other compounds of lime as are changed into the carbonate by decomposition within the soil all tend to favor the production of potato scab, provided the germs of the disease are already in the soil or are introduced into it on the seed tubers. This seems to be due to the fact that the lime makes the soil alkaline or to some influence which the combined carbonic acid of the carbonate of lime exerts upon the development of the fungus. In view of this unfavorable action of lime caution should be observed in liming potato fields.

Club Root.—Many writers seem to agree that liming is capable of lessening materially the injury to turnips, cabbages, etc., caused by the disease known as "finger-and-toe" and "club root." English writers assert that by resort to liming excellent crops of turnips have been produced where without it the crop was a failure, owing to the attacks of the disease.

Other Diseases.—The effect of different compounds of lime has been tested, with not entirely conclusive results, on various other diseases, including cranberry and sweet potato diseases, and a root disease of alfalfa (*Rhizoctonia medicaginis*). Slaked lime was found to be effective in reducing soil rot of sweet potatoes, and quicklime in checking or preventing the root disease of alfalfa.

How Often Should Liming Be Practiced?—The frequency with which liming should be practiced depends upon several conditions; for example, upon the character of the soil, the quantity of lime employed in each application, the number of years involved in a rotation, the plants to be grown and their order of succession. Formerly, in England, large quantities of lime were applied at somewhat rare intervals, but there and elsewhere at the present time the preferable practice seems to be to use small amounts and apply it more frequently. As a general rule it may be stated that from half a ton to one and a half tons of lime per acre applied every five to six years is sufficient. There may exist extreme soils requiring either more or less than these amounts. If soils which are quite acid and have not previously been limed are to be seeded, with the intention of allowing them to remain in grass for several years, as much as two or three tons of lime per acre may sometimes be advisable. Only very extreme cases would call for larger applications. If in a rotation covering a considerable number of years two crops especially benefited by lime are introduced at about equidistant intervals of time, it may be advisable to lime twice in the course of the rotation, each time just prior to their introduction. In renovating acid pastures and meadows it is usually preferable to apply a fair amount of lime upon the furrows when they are first plowed, so that this may be thoroughly mixed with the soil by subsequent plowing and harrowing, and just prior to seeding to grass make another generous application. By such treatment, provided the other essential fertilizing ingredients are employed, a good stand of clover, Kentucky bluegrass, timothy, and other grasses may be obtained where in many instances they were formerly partial or total failures and where only redtop, Rhode Island bent, and grasses having similar soil adaptability could be grown. Where land is kept in grass for a number of consecutive years, top-dressing with lime or, preferably, wood ashes may possibly be advisable in some instances, particularly if ordinary commercial fertilizers are employed in lieu of stable manure. If home-mixed dressings containing basic slag meal or liberal amounts of bone are used with nitrate of soda or nitrate of potash, the need of liming is much less than under many other circumstances.

When to Apply Lime.—Lime in the form of carbonate of lime, as in marl, wood ashes, etc., can usually be applied with safety in the spring or at any other season of the year, but autumn is always the safest time to apply caustic or slaked lime. The latter form upon further exposure to the air changes gradually into the mild carbonate of lime, but usually a considerable quantity has not reached that stage when applied and it may in consequence act too energetically. This is particularly true if the soil is light and sandy, and if plants, which are but little helped by lime, are employed. On very acid soils, particularly such as contain much humus, there is little or no danger from applying reasonable quantities of lime in the spring. If caustic or slaked lime is applied in excessive amounts it may not only injure plants directly, but also indirectly by rendering the texture of the soil unfavorable; it may also make the soil temporarily so alkaline as to interfere with the activity of the organisms which transform ammonia into readily assimilable nitrates. Injury thus arising can not ordinarily be of long duration, for the reason that the carbonic acid of the soil changes the caustic lime rapidly into carbonate of lime, and thus the alkalinity of the soil is soon reduced.

How to Apply Lime.—Some writers recommend that upon old mossy meadows and pastures lime should be applied to the surface before plowing, in order that it may help to quickly decompose the organic matter. The chief objection to this procedure is that the lime does not become well incorporated with the soil, and since some of it is turned to the bottom of the furrow and its tendency at all times is to work downward, it may be quickly carried not only away from the surface soil, but also from the reach of plants. The practice of liming such soils immediately after plowing and then thoroughly harrowing has been attended by excellent results. This is particularly the case provided a second application is made in a similar manner just previous to reseeding. Under such a plan some lime becomes intimately mixed with the entire mass of soil by the operations of tillage, and finally a considerable amount is left near the surface, thus accomplishing two important objects.

In some sections where marl is used extensively it is spread upon the surface and plowed under, turning a furrow about 2 inches deep. The more common method where marling is practiced is to plow the land and then cart on the marl, dumping it in heaps at such intervals that it can be spread conveniently with a shovel. If the marl is not sufficiently fine, but is of such a nature that it crumbles upon exposure to the air, the heaps may be allowed to remain for some time before spreading, and still further time may be allowed to elapse before the operation of harrowing is begun. Sometimes a clod crusher or bush harrow may be employed to advantage to break up the lumps before harrowing. A most important point to be observed in applying lime of all kinds is to mix it with the soil as thoroughly as possible, the finer the particles the better being the result.

Pulverized Burned Lime or lime which is already slaked may be spread upon the soil directly from wagons or carts, or dumped in heaps and then spread with a shovel, though the most satisfactory plan in such cases is to employ an ordinary grain drill with fertilizer attachment or a lime spreader. In the use of such spreaders it is generally advisable to attach some burlap or old bagging to the sides and rear of the machine in such a way that it will trail upon the ground. If the machine is so equipped and the burlap is weighted with a piece of wood at the rear, much of the unpleasantness connected with spreading lime is avoided. For those familiar with the nature of lime and its use it is unnecessary to state that it is well, if possible, to apply it on a quiet day. The eyes may be protected by glasses and the nostrils and mouth by devices used by those who run thrashing machines.

The only other form of lime in connection with the application of which any particular difficulty might be encountered is quick or burned lime in lump form. Where only small quantities of such lime are to be used it is frequently immersed for a moment in water, in a basket, and emptied into a wagon body. The following day it will be slaked sufficiently for use. Where larger quantities are used, and a lime spreader is at hand, the lime is sometimes water slaked in large piles on the border of the field and then distributed. To accomplish the water slaking in a satisfactory manner, from 2 to 2½ pails of water should be sprinkled over each cask of lime as it is emptied upon the pile, and finally the whole mass should be very thoroughly covered with soil. In a few days practically all of the lime will be in a fine condition suitable for spreading. In loading it into the spreader care should be taken to first remove the soil, so as to avoid its clogging the machine. If the lime spreader itself is not fitted with a screen, the lime should first be carefully screened for the purpose of removing any hard lumps which may remain, due to imperfect slaking or burning. These lumps may be further slaked by themselves.

A practice preferred by many, and probably the most feasible one where a lime spreader is not to be had, is to place the burnt lime in piles of from 35 to 40 pounds each at suitable intervals (heaps of this size 20 feet apart in each direction furnish about 2 tons per acre), and cover the piles with moist earth. In a few days the lime is so thoroughly slaked that it can be spread directly with a shovel. Provided the soil is dry, from one-fourth to half a pail of water (or in extreme cases even more) should be sprinkled over each pile immediately before it is covered with earth. In this case, as in all others where slaked lime is employed, it is important that it be harrowed into the soil immediately after spreading. In no case should it be exposed long to the air before harrowing, as it is liable to cake and form a sort of mortar to such an extent that it is impossible to mix it as thoroughly with the soil as before.

FORMS OF LIME USED FOR AGRICULTURAL PURPOSES.

Caustic (quick or burnt) lime obtained by burning oyster shells, limestone, etc., is the most economical form in which lime can be bought, in all cases where the distance of railway transportation or of cartage is great. One hundred pounds of such lime usually contain about 95 pounds of actual lime. Sometimes burned lime contains considerable magnesia.

Gypsum, or land plaster, is a combination of lime with sulphuric acid (oil of vitriol) and water. Upon heating, gypsum loses its water and is changed into plaster of paris or calcined plaster, which is used in making casts and for many other industrial purposes.

In case a soil is seriously deficient in lime, gypsum may act as a direct manure; usually, however, its beneficial effect upon soils is attributed to its indirect action in liberating potash, and possibly other substances, which were locked up in the soil in such combinations that plants could not make use of them. Gypsum may be helpful to a limited extent on clayey soils by flocculating the fine particles, on account of which the soil is less likely to become water-logged and to cake, and hence interfere with the operations of tillage. In the last-mentioned respect water-slaked lime or the carbonate is said to be much more efficacious than gypsum, though as a liberator of potash gypsum is claimed to lead.

It is stated on good authority that, in the presence of decaying organic matter, gypsum may be changed into carbonate of lime. While this may be true under certain circumstances, in experiments at the Rhode Island Station on a soil exceptionally rich in humus and containing a moderate amount of plant residues which were undergoing decomposition, such a change did not result, if at all, to a practical extent. For this reason and on account of the fact that gypsum contains only about one-third as much lime as burned lime, and usually costs as much or more per ton, it can not take the place of the latter for most of the purposes for which lime is applied to land.

For use in renovating black alkali (sodium carbonate) soils in the arid regions, gypsum, as already explained, performs a valuable function which cannot be filled by any of the other compounds of lime. Chalk is a naturally occurring form of carbonate of lime which is exceptionally pure. It is quite soft, and is frequently referred to as marl.

Marl is a name which is applied to earthy deposits usually more or less friable in their character and containing carbonate of lime in quantities ranging usually from 5 to 95 pounds per 100 pounds of the material. It must be evident, therefore, that if one intends to make use of a given deposit of marl for the lime contained in it, he should first have a sample of it analyzed. If the material will not effervesce upon the addition of either hot or cold vinegar, it probably contains but little carbonate of lime and may be of doubtful value. This test, however, should precede, and not be substituted for, a careful chemical analysis.

On account of the varying chemical composition of marl, it must be obvious also that no definite rules as to the amounts which should be used in given cases can be stated. On a soil where one has reason to think a ton of burnt lime should be applied per acre, about 4 tons of a marl containing from 20 to 25 per cent of actual lime (calcium oxid) should be employed. If the marl is twice as rich the amount applied should be but 2 tons, etc.

Marls vary somewhat in their physical characteristics, depending upon the amounts and character of the earthy material associated with the carbonate of lime. If the marl is associated with clay it is exceptionally well adapted for use on sandy soils, since the clay and carbonate of lime both tend to make such soils more compact and retentive of manures and moisture. A marl containing sand would, on the other hand, be better suited to clayey soils. According to Heinrich, sand marl may be applied to the soil immediately, but clay marls sometimes contain injurious compounds of iron and sulphur, in which case it is not safe to use them until they have been composted for two or three years, or long enough to effect the decomposition of the iron compounds. Some so-called marls contain considerable quantities of phosphoric acid and potash in such forms as to greatly enhance their fertilizing value.

Phosphate of lime is found as bone, guano, apatite, and in the form of the well-known South Carolina, Florida, and Tennessee phosphate rock. The better classes of phosphate rock contain but small quantities of carbonate of lime, while others contain large amounts. The latter are unfitted on this account for superphosphate manufacture. Both classes of phosphate when ground finely have been found to be more or less effective upon acid soils, particular attention having been devoted to their employment on acid muck or peat soils. These phosphates not only seem to materially reduce the acid character of such soils, but after having been in contact with them for some time the assimilability of the phosphoric acid seems to materially increase. The lower-grade phosphates containing considerable quantities of carbonate of lime are particularly effective upon acid soils.

In employing undissolved phosphate rock upon acid soils, certain authorities recommend following the application of the phosphate at an interval of some months, or, if possible, a year, with a dressing of lime. This seems to be a reasonable recommendation provided the plants to be grown are not injured by soil acidity.

Superphosphates, which are prepared by treating phosphate rock, bone, and boneblack with sulphuric acid, generally have about one-third of their lime combined with phosphoric acid and two-thirds with sulphuric acid. The lime combined with sulphuric acid is nothing more nor less than gypsum (land plaster). For this and other reasons superphosphates may not work as well on acid muck or peat soils as ordinary undissolved phosphate rock or ground bone, and if, as is sometimes the case, a slight excess of sulphuric acid is present they may even have a temporary injurious action upon upland soils which are deficient in carbonate of lime.

Basic slag (Thomas slag or slag meal) is a waste product obtained in the manufacture of steel. It contains relatively more lime than the ordinary high-grade phosphates, and the phosphoric acid in most cases (a few works have put an inferior product on the European market) is possessed of a high degree of assimilability. This product is as yet too little known in this country, and if sold here as cheaply as it might be it would doubtless prove of great value to our agriculture. It is an effective source of phosphoric acid for use upon all kinds of soils, and on account of its high percentage of lime it is of special promise in the reclamation not only of acid upland soils, particularly if rich in organic matter, but also of marsh or muck soils.

Unleached wood ashes contain about 35 pounds of actual lime (calcium oxid) in every hundred, 3 tons being, therefore, a little more than equivalent, in lime, to 1 ton of burned lime. They also contain from 5 to 7 per cent of potash, 1 to 2 per cent of phosphoric acid, and from 3 to 5 per cent of magnesia. This latter ingredient, though usually ignored, is of approximately as much value as lime on acid soil. Soils are sometimes deficient in magnesia, and when this is the case the magnesia applied in ashes has a direct manurial action.

Leached wood ashes contain usually less than 1 per cent of potash and rather more lime than unleached ashes. Frequently they are sold in a wet condition, which of course lessens the quantity of actual lime present in a ton.

Limekiln ashes often contain approximately 40 per cent of lime, and when wood is employed in the burning instead of coal they sometimes contain 2 per cent or more of potash.

Finely ground limestone and oyster shells can be used to advantage, if obtainable, especially upon sandy soils. They are not as efficacious as after burning upon heavy clay soils and such soils as are very acid and contain large amounts of sour humus. This is for the reason that they are not so active chemically, and they can not be reduced to so fine a state before burning as afterwards.

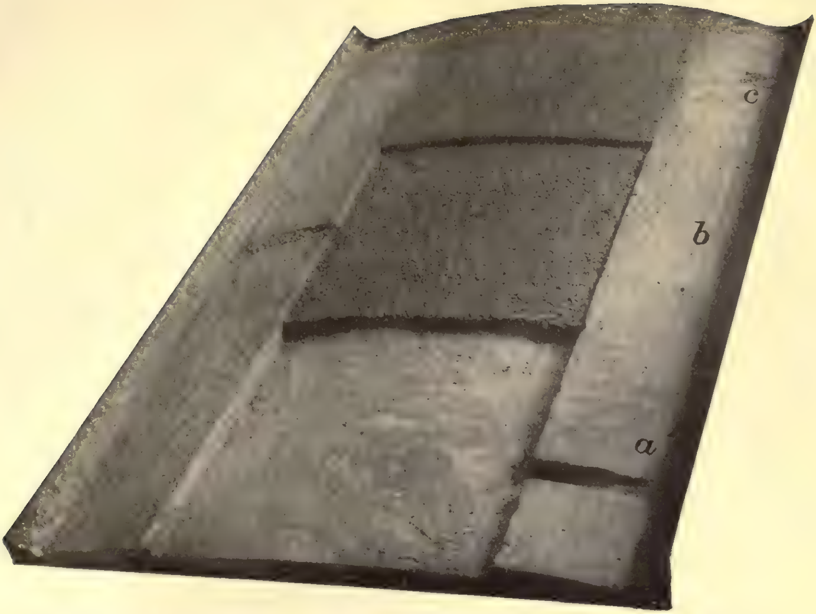
Dye-house lime usually contains only a small percentage of lime, and if moist can not be transported long distances at a profit. A rule that applies well to this and all other waste products of a similar character is not to use them until they have been subjected to chemical analysis, for by changes in the processes of manufacture their value may be materially influenced and substances injurious to vegetation may have found access to them.

Gas-house lime.—It is never safe to use this substance until it has first been allowed to weather for several months. On acid soils such lime is less effective than burned lime, wood ashes, and limekiln ashes. Owing to recent changes in the process of gas manufacture, lime is used less than formerly.

Waste lime from beet-sugar factories may be effectively applied to soils after it has been allowed to dry. It contains some potash, phosphoric acid, and nitrogen, which still further increase its value. If this material is applied to the soil in a wet condition it tends to cake in the same manner as water slaked lime does when not immediately worked into the soil. It is sometimes put in piles by itself and worked over every few weeks. It may also be dumped in the field during the winter in small piles, where it is allowed to remain until spring, when, after drying sufficiently, it may be spread and incorporated with the soil. According to Heinrich, this material contains: Water, 35 to 60 per cent; nitrogen, 0.1 to 0.4; potash, 0.1 to 0.3; phosphoric acid, 0.5 to 1.5, and lime, 15 to 30 per cent. It is evident that this waste material in its moist condition could not be transported to any considerable distance at a profit, and in this country, where labor is such an important item, it would not pay to shovel it over much in order to get it into condition to use.

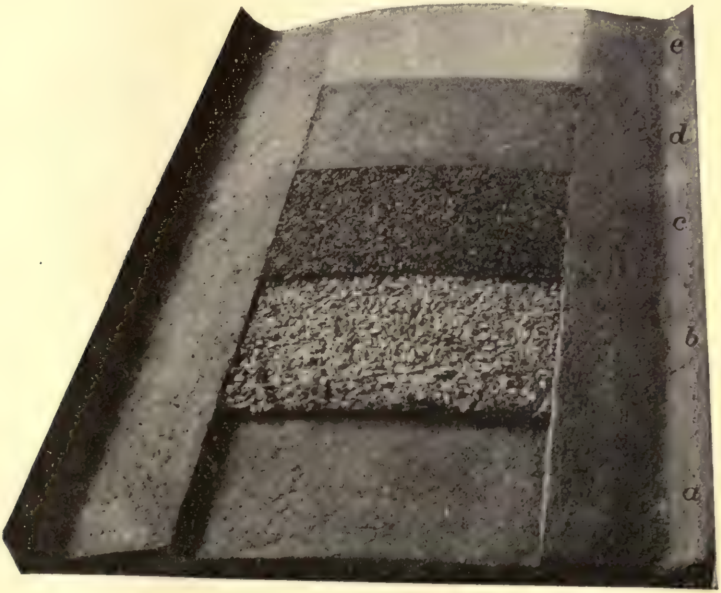
Waste lime from soda-ash works usually contains considerable water, and can for this reason only be employed to advantage where the cost of transportation is small. If some economical means of drying it could be devised, the range of distance to which it could be profitably shipped would be much increased.

From the preceding statements regarding the different kinds of lime used for agricultural purposes, it is evident that it is impossible to state definitely for all locations and conditions which kind is most economical to employ. This is still more evident when one considers that the character of the soil and of the crop to be grown, as well as the market prices, must be taken into account. Caustic or quick lime is the most concentrated, and consequently the most economical to handle. Its caustic properties, however, render it more vigorous in its action than the milder sulphate (gypsum) or carbonates (limestone, chalk, wood ashes, marl, etc.), and thus better suited for application to soils which are rich in organic matter than to light soils deficient in this substance. It is also especially suited to correcting acidity in sour soils. There may be special reasons in particular cases why some of the other compounds of lime are preferable to quicklime. Gypsum has been used in agriculture to a considerable extent with very satisfactory results. On account of its peculiar composition it has been found especially valuable for neutralizing sodium carbonate (black alkali) in alkali soils. Wood ashes are used extensively in some localities, in many cases as much for the lime as for the potash which they contain. It is very doubtful, however, whether it would not be more economical at the present prices of wood ashes and caustic lime to employ the latter in many cases, supplementing the lime with potash salts and other fertilizing materials if the latter are required by the soil. The item of transportation is also decidedly in favor of the use of lime and agricultural chemicals as substitutes for ashes.



Model of Gravel Macadam Road. Dept. of Agr.

(See pages 149-165.)



Model of Sand-Bituminous Macadam Road. Dept. of Agr.

Authorities Consulted.—Md. E. S. B. 110; F. B. 77; Bu. Plt. Ind. 1, 21; Mass. E. S. B. 137; Cornell Univ. B. 7; W. Va. E. S. B. 80; Wash. E. S. B. 19; Va. E. S. B. 187; Tenn. E. S. B. 86; R. I. E. S. B. 96; O. E. S. Bs. 79, 159; N. H. Ag. Col. Bs. 13, 83; Mich. Ag. Col. B. 11; Ill. Univ. B. 116; Purdue Univ. B. 10; Ala. Agr. Dept. Bs. 2, 9; Fla. E. S. B. 2.

TERMS USED IN DISCUSSING FERTILIZERS.

Complete fertilizer is one which contains the three essential fertilizing constituents, i. e., nitrogen, phosphoric acid, and potash.

Nitrogen exists in fertilizers in three distinct forms, viz., as organic matter, as ammonia, and as nitrates. It is the most expensive fertilizing ingredient.

Nitrates furnish the most readily available forms of nitrogen. The most common are nitrate of soda and nitrate of potash (saltpeter).

Nitrification is the process by which the highly available nitrates are formed from the less active nitrogen of organic matter, ammonia, salt, etc. It is due to the action of minute microscopic organisms.

Phosphoric acid, one of the essential fertilizing ingredients, is derived from materials called phosphates. It does not exist alone, but in combination, most commonly as phosphate of lime in the form of bones, rock phosphate, and phosphatic slag. Phosphoric acid occurs in fertilizers in three forms—soluble, reverted, and insoluble phosphoric acid.

Superphosphate.—In natural or untreated phosphates the phosphoric acid is insoluble in water and not readily available to plants. Superphosphate is prepared from these by grinding and treating with sulphuric acid, which makes the phosphoric acid more available to plants. Superphosphates are sometimes called acid phosphates.

Potash, as a constituent of fertilizers, exists in a number of forms, but chiefly as chlorid or muriate and as sulphate. All forms are freely soluble in water and are believed to be nearly, if not quite, equally available, but it has been found that the chlorids may injuriously affect the quality of tobacco, potatoes, and certain other crops. The chief sources of potash are the potash salts from Stassfurt, Germany—kainit, sylvinit, muriate of potash, sulphate of potash, and sulphate of potash and magnesia. Wood ashes and cotton-hull ashes are also sources of potash.

TERMS USED IN DISCUSSING FOODS AND FEEDING STUFFS.

Water is contained in all foods and feeding stuffs. The amount varies from 8 to 15 pounds per 100 pounds of such dry materials as hay, straw, or grain to 80 pounds in silage and 90 pounds in some roots.

Dry matter is the portion remaining after removing or excluding the water.

Ash is what is left when the combustible part of a feeding stuff is burned away. It consists chiefly of lime, magnesia, potash, soda, iron, chlorin, and carbonic, sulphuric, and phosphoric acids, and is used largely in making bones. Part of the ash constituents of the food is stored up in the animal's body; the rest is voided in the urine and manure.

Protein (nitrogenous matter) is the name of a group of substances containing nitrogen. Protein furnishes the materials for the lean flesh, blood, skin, muscles, tendons, nerves, hair, horns, wool, casein of milk, albumen of eggs, etc., and is one of the most important constituents of feeding stuffs.

Albuminoid nitrogen is nitrogen in the form of albuminoids, which is the name given to one of the most important groups of substances classed together under the general term protein. The albumen of eggs is a type of albuminoids.

Amid nitrogen is nitrogen in the form of amids, one of the groups of substances classed together under the general term protein. Amids, unlike albuminoids, are usually soluble in water, but are generally considered of less value as food than albuminoids.

Carbohydrates.—The nitrogen-free extract and fiber are often classed together under the name of carbohydrates. The carbohydrates form the largest part of all vegetable foods. They are either stored up as fat or burned in the body to produce heat and energy. The most common and important carbohydrates are sugar and starch.

Fiber, sometimes called crude cellulose, is the framework of plants, and is, as a rule, the most indigestible constituent of feeding stuffs. The coarse fodders, such as hay and straw, contain a much larger proportion of fiber than the grains, oil cakes, etc.

Nitrogen-free extract includes starch, sugar, gums, and the like, and forms an important part of all feeding stuffs, but especially of most grains.

Fat, or the materials dissolved from a feeding stuff by ether, is a substance of mixed character, and may include, besides real fats, wax, the green coloring matter of plants, etc. The fat of food is either stored up in the body as fat or burned, to furnish heat and energy.

MISCELLANEOUS TERMS.

Humus is the name applied to the partially decomposed organic (animal and vegetable) matter of the soil. It is the principal source of nitrogen in the soil.

Micro-organism, or microscopic organism, is a plant or animal too small to be seen without the aid of a compound microscope.

Fungus (plural, Fungi) is a low form of plant life destitute of green coloring matter; molds and mushrooms are familiar examples. Many diseases of plants are due to fungi.

Bacterium (plural, Bacteria) is the name applied in common to a number of different or closely related microscopic organisms, all of which consist of single short cylindrical or elliptical cells or two such cells joined end to end and capable of spontaneous movement. Many kinds of bacteria are harmful and cause diseases and other injurious effects, but many are beneficial. Among the latter are those which give flavor to butter and cheese, and those which enable leguminous plants to use the free nitrogen of the air.

Pollen is the powdery substance, usually yellow or brown, which falls from flowers when they are shaken.

Pollination is the act of conveying pollen to the part of the flower prepared to receive it. Pollination may be brought about either by natural agencies, such as wind, insects, etc., or by artificial means.

Self-fertile plants or varieties are those which do not require pollen from other plants or varieties in order to produce seeds or fruit.

Self-sterile plants or varieties are those which do require pollen from other plants.

Lactation is the formation or secretion of milk. The period of lactation as applied to cows means the length of time since calving that they have been giving milk.

Authorities Consulted.—F. Bs. 44, 48, 56, 77, 192, 245, 278, 286, 315, 398; Bu. Plt. Ind. Bs. 1, 22, 51, 63, 71, 76, 134, 404, 441, 692; Bu. Soils Bs. 55, 58, 62, 67, 69, 76; Y. B. 1909; Ala. Ag. Dept. Bs. 9, 10, 2; Univ. Ariz. B. 45; Ark. E. S. B. 46; Calif. Univ. Bs. 23, 157, 173, 179, 187, 194; Colo. Ag. Col. Bs. 99, 115, 168, 178, 179; Conn. E. S. Repts. 1900, 1902, 1903, 1905, 1906, 1907, 1908; Del. Ag. Col. B. 60; Fla. E. S. Bs. 2, 10, 20, 50; Ga. Ag. Col. B. 72; Pur. Uni. Bs. 10, 18, 88, 92, 106; Uni. Ill. Bs. 94, 109, 115, 116, 129, 130, 140, 160; La. E. S. B. 31; Md. E. S. Bs. 122, 126, 151; Mass. E. S. Bs. 51, 137; Mass. Ag. Col. Bs. 9, 10, 14, 18, 81, Special B., 45, 94, 102; Rept. Mass. E. S. 1907; Md. E. S. Bs. 110, 122; Mich. E. S. B. 11; Mich. Ag. Col. B. 231; Miss. E. S. B. 99; Md. E. S. B. 128; N. H. E. S. Bs. 5, 12, 13, 21, 140; N. H. Ag. Col. Bs. 26, 83, 88, 108; Cornell Univ. Bs. 7, 201, 241; Cornell R. C. 9; N. Y. E. S. Bs. 192, 205, 206; Univ. Minn. B. 34; N. C. E. S. Rept. 1887, B. 77; O. E. S. Bs. 54, 59, 69, 79, 83, 114, 124, 134, 167, 125, 141, 159, 161, 168, 172, 183, 182, 184, 206; Ore. E. S. B. 79; Pa. Ag. Col. Bs. 35, 49, 54, 63; Clemson Ag. Col. Bs. 4, 12, 15, 18, 21; Univ. Tenn. Bs. 1, 3, 86, 92; Univ. Tenn. Rept. 1899; Tex. E. S. Bs. 85, 107, 112, 115, 84, 138; Univ. Vt. B. 154; Va. E. S. B. 187; W. Va. E. S. Bs. 28, 40, 51, 80; Univ. W. Va. Bs. 97, 99, 101, 112, 114; Wash. E. S. Bs. 19, 32, 37; Wash. Ag. Col. B. 98; Univ. Wis. B. 180; Univ. Wyo. B. 44; R. I. E. S. Bs. 71, 90, 95, 96, 104, 114, 106, 118, 129, 142, 143, 147; Ont. Agr. Dept. Bs. 164, 169.

PLANT INOCULATION.

Plant inoculation for the restoration of nitrogen to exhausted soils is comparatively a recent discovery. In fact the whole science of bacteriology is comparatively new. When Dr. Rudolph Virchow announced a few years ago that the diseases of the human body are the results of an injurious environment of the body cells, he laid the foundation of the science of bacteriology. Dr. Louis Pasteur put forth the theory that fermentation is caused by germs in the air. Dr. Emil Roux, another advocate of the germ theory, discovered and identified the bacillus of diphtheria and a serum for the cure of that disease, receiving in 1903 the Osiris prize of $4,000. Another laborer in the field of bacteriology, Dr. Metchnikoff, advanced the theory that the apparent old age of men and women is caused by the presence of harmful germs in the intestines. He also discovered that lactic ferments largely destroy such harmful germs. Boiled water, cooked meats and stewed fruits contain lactic ferments. He is also the father of the doctrine that appendicitis is produced by small intestinal worms, and he developed a serum to combat the disease. He was the assistant to Dr. Koch in discovering the cause and cure of sleeping sickness. Prof. Emil Behring discovered an antitoxin for diphtheria, and claims to have found a cure for tuberculosis. He claims to be able to wholly eradicate the disease in its earlier stages, and to arrest it after it has been well started. He calls his discovery a curative principle. Prof. Ehrlick discovered the manner in which the animal body is able to produce antitoxins. He also discovered a cure for diseases of the blood, and arseno-phenyl-glycin, a bright yellow powder, a cure for sleeping sickness.

By discovering a method for artificially coloring bacteria, Dr. Koch made a great advance in the identification of germs. He has also devoted much study to tuberculosis and cholera. He spent eighteen months in Africa studying the sleeping sickness and found that tsetse flies carried the disease germs from crocodiles and hippopotami. The discoveries in bacteria in the human system led to a study of bacteria in plants and in the soil and their effect on plant life. This study has already resulted in some discoveries that are destined to prove of inestimable value to agriculturists.

Plants and Plant Food.—Plants are composed of the elements carbon, hydrogen, oxygen and nitrogen together with other elements. Of these the first three are furnished in the carbonic acid gas present in the air and in the soil water. The fourth element, nitrogen, is one of the gases of the atmosphere and is therefore abundantly supplied to such plants as are capable of utilizing it. For their growth plants must have these elements supplied in their food in some available form. All plants must have nitrogen.

Nitrates can be artificially supplied to growing crops as a commercial salt-like nitrate of soda. Within the soil nitrates are being elaborated on a large scale out of the nitrogenous organic matter of the soil through the agency of soil bacteria. Rain will supply from 1.75 to 3.75 pounds of nitrogen per acre per annum as nitric acid and as ammonia, but this amount is totally insufficient to meet the demands of growing crops and this deficiency must be supplied by other means. This is done by means of bacteria in the soil or plant. —(Del. Col. B. 40.)

What Are Bacteria?—Bacteria are plants. Although they were formerly classed as animals, it is now universally conceded that they are plants. They are single-celled and of simple structure, being composed almost entirely of protoplasm; they differ from higher plants in that they contain no chlorophyl (green coloring matter). They resemble more closely the yeasts and molds. There are many different varieties of bacteria; about 1,200 different kinds have been isolated and studied, and new varieties are being found every day. Bacteria are very small, being invisible to the naked eye. It would take about 10,000 average-sized bacteria placed end to end to make an inch in length, or it would take about one and one-half millions in a cube to make a mass large enough to be seen with the unaided eye. Bacteria are omnipresent. They are in the air we breathe; in the crust of the earth; on trees, grass, hay, flowers, fruit, vegetables; in lakes, creeks, rivers, oceans, the water we drink, in our food—in fact, they are everywhere, except in the interior of the earth and the upper layers of the atmosphere. A fertile soil teems with countless millions of various kinds of micro-organisms constantly active in breaking down and nitrifying organic matter. The food requirement varies according to the species. As a rule, bacteria, like other non-chlorophyllic plants, require performed organic food; although some soil bacteria apparently thrive best, or only on mineral foods. Generally speaking, bacterial food resembles closely the food of man; thus, milk, an excellent human food, is also an excellent bacterial food. Bacteria digest their food by ferments secreted by their bodies; the process in general is the same as that of man. The food thus digested is absorbed by the bacteria, a part of it being used in the construction of new protoplasm, and a part to produce energy in the form of heat, motion, and possibly light.—(Y. B. 1902; Kansas Ag. Col. B. 117.)

Nitrogen Necessary.—Nitrogen is absolutely essential to all plant life. It is a part of plant food that must be supplied if the soil does not contain it, and at the same time it is the most costly if the farmer has to buy it. Under normal conditions this nitrogen must be obtained by the plants through the roots in some highly organized form. Other substances, such as phosphoric acid, potash, iron, etc., which plants must have, can be obtained through the soils, but nitrogen is so much greater and in one sense so much more important that the question of the available nitrogen supply in the world has come to be looked upon as lying at the foundation of agriculture and demanding the most careful consideration.

How Nitrogen Is Lost.—In the first place, the conditions of life on the ordinary farm are such as to cause the constant loss of this valuable element through the removal of the crops taken from the soil. If every crop that grew on the land could be returned to it, nature has made provision for getting it back in suitable form for plant food. In the case of nitrogen, neither plants nor animals are able to produce this substance directly in an available form. It is necessary that certain bacteria take hold of plant and animal products, and by means of peculiar changes produce nitrates from their fats, sugars, starches, etc. Without these bacteria everything would have come to a standstill long ago, for unless decay takes place and the decomposed elements are rearranged into definite nitrogenous salts no plant is able to use them. Thus, it will be seen that certain bacteria in the soil play as important a part in the food supply of the earth as do the animals and larger plants upon which we think we are so dependent.

It is hardly necessary to refer to the vast waste of nitrogenous material that is involved in modern sewage methods. Millions of dollars' worth of nitrogen which would naturally return to the soil under the action of nitrifying bacteria is every year carried off in various waterways and ultimately reaches the ocean, where, of course, it is of no benefit to man.

A third great source of nitrogen loss is through the action of a group of bacteria which have the power of breaking down nitrates, depriving them of oxygen, and reducing them to ammonia or nitrogen gas, when they are, of course, unavailable for plant food. This process of denitrification, while very useful in the septic tank, which is the most sanitary method of sewage disposal, is the source of considerable loss to the farmer, and manures may often be rendered practically worthless by the action of these bacteria.

Other means by which nitrogen is lost so far as plant foods are concerned, are the washing out of nitrogen salts from the soil and the burning of explosives which are largely composed of some nitric salt that would be directly valuable to the vegetable kingdom. Of the three important elements nitrogen is the most easily lost to the farmer by washing of the soil.—(Ont. Agr. Dept. B. 148; Y. B. 1902.)

Nitrogen Must Be Supplied.—No soil where plants of any kind will grow is wholly devoid of nitrogen, but some soils are much more abundantly supplied with this valuable element than others. The quantity of nitrogen present in soils in the form of organic matter (humus) may vary from one-tenth to two-tenths of one per cent in the surface layers, or 7,000 to 28,000 pounds per acre in the first three feet. Since from each acre of such land fifteen bushels of wheat would remove about twenty-five pounds, and one ton of clover hay about fifty pounds of nitrogen, it is easy to understand that the majority of agricultural soils contain within themselves a store of nitrogen sufficient for many years to come. But before the nitrogen thus locked up in soils in the form of organic matter can be made available to plants it must undergo a series of complex chemical changes, through the agency of bacterial life, by which the nitrogen of said organic matter is converted into ammonia and finally into nitric acid.

Some plants take much more nitrogen from the soil than do others, and when grown continuously they exhaust the available supply. The sources of nitrogen supply are: (1) The nitrogen already contained in the soils; (2) that supplied to the soil by the decay of organic matter; (3) the fixation of atmospheric nitrogen. The air is a mechanical mixture of oxygen and nitrogen—about 4 parts of the latter to one of the former.

The nitrogen in soils is of two types: (1) The ammonia, nitrites, and nitrates, in which forms it is available to crops; and (2) the nitrogen locked up in organic matter and not directly available. The nitrate nitrogen (nitrogen in the form of nitrates) is in most soils present only in small quantity. This supply is quickly taken out by crops or washed out by rains, and if it is not renewed by the action of certain bacteria on the nitrogenous organic matter in the soil or from the atmosphere by other bacteria it must be added directly as nitrate of soda or nitrate of potash, or some other manure must be used containing directly available nitrogen. Manures containing directly available nitrogen are very expensive. The best of these is nitrate of soda, and at the present rate of use the known supply will be exhausted in less than fifty years.—(Y. B. 1906; Y. B. 1909; Bu. Plt. Ind. B. 101; Del. Col. B. 40.)

The fertility of the soil is dependent largely upon the availability of the plant food contained in the soil. In some soils the plant food is not available because it has not been set loose by the action of bacteria, by cultivation, or by some other process.

The supply of nitrogen in the soil being exhausted by the growing of crops it must be restored by some means. The principal means for restoring nitrogen to depleted soils are: (1) Application of barnyard manure; (2) use of commercial fertilizers; (3) growing of leguminous crops which have been infected with nitro-fixing bacteria and which take nitrogen from the air and store it within the plants. The supply of barnyard manure is insufficient to make up for the losses of nitrogen occasioned by ordinary cropping, and other means of supply must be resorted to.

Ever since the importance of increasing the combined nitrogen supply has been realized, men of science have naturally turned to the atmosphere as being the most promising field for experiment and the one most likely to eventually solve the whole problem. When it is remembered that nearly eight-tenths of the air about us is nitrogen, and that plants are able to obtain their entire source of carbon from a gas which is present in the comparatively small proportion of one-tenth of 1 per cent, it seems almost incredible that there should be any more difficulty about a plant's nitrogenous food than about its supply of carbon dioxid. Since it seemed so well settled, however, that plants could not use nitrogen as a gas, the chemists and physicists have made every effort to devise some mechanical means of making this element available in a combined form. It has been known that discharges of lightning passing through the air are able to fix free nitrogen, and, beginning with this as a basis, some very satisfactory results have been obtained by the use of electricity. With a power sufficiently cheap and with perfect machinery, there seems good reason to believe that in the near future it will be possible to place upon the market a manufactured nitrate of soda or nitrate of potash that will be superior in quality to the deposits found in South America, and that will also be reasonable enough in price to compete with the natural product.—(Y. B. 1902.)

Bacteria the Agents of Supply.—The organic matters which are added to the soils in manures and in vegetable and animal remains must go through certain processes of decay before the plant foods they contain become available to plants. Bacteria and fungi are the active agents which bring about these changes. Decay is not a simple process, the same in all places and under all conditions. The process varies when the same materials under the same conditions are acted upon by different organisms or groups of bacteria which produce it.

In general, organic materials contain three classes of compounds: (1) The nitrogenous or albuminoid compounds like flesh and blood of animals and the protoplasm of plant cells; and (2) the non-nitrogenous compounds or the carbohydrates (such as sugars, starches and cellulose); and (3) the hydro-carbons or fats. The first class contains the nitrogen formerly taken from the soil as nitrates by some plant, but which in its highly organized form is unavailable for crops until converted into ammonia or nitrates again by certain bacteria. The compounds of the second class serve as food for certain bacteria which are enabled to obtain nitrogen from the air.

Fortunately, there are still other means by which nitrogen gas may be made available for plant food, and that, too, without requiring the introduction of a commercial product, which must always be rather expensive, whatever degree of perfection may be reached in the mechanical operation of the process. Ever since the earliest days of agricultural science it has been noticed that certain land, if allowed to stand fallow for a considerable length of time, would gain in nitrates without any visible addition having been made. It is now known that one of the principal means of this increase in nitrogen content is due to a few forms of soil bacteria which have the power of fixing the free nitrogen from the air and rendering it available for plant food. These organisms have been isolated and cultivated artificially, and great hopes were held at one time that it would be possible to inoculate land with these cultures and thus bring about a large increase in the nitrogenous salts without the aid of any manure or mineral fertilizer. Under certain conditions these bacteria seemed able to do a large amount of work, and there are experiments on record where the crops raised from plots inoculated with nitrogen-fixing organisms were much greater than crops from uninoculated land.

Ever since the time of Pliny and other early writers upon agricultural topics, it has been known that certain leguminous crops, such as clover, beans, peas, etc., did not require the same amount of fertilizer as other plants, and indeed it seemed as though they actually benefited the soil instead of being a detriment. Various theories have been advanced to account for this effect, perhaps the most widespread opinion being that members of this family, owing to the unusual length and strength of their root system, were able to draw upon a store of food that was not available to wheat and corn and other crops not belonging to the pod-bearing group. It is only within a comparatively recent time that the real cause of the beneficial effect of these legumes has been fully understood, and it seems that here again the bacteria are responsible for the nitrogen-gathering power; for it is because these plants are able to fix and use the free nitrogen of the air that they are of such benefit in rotation and in reviving poor and exhausted land. The immense yields of wheat following alfalfa or clover are easily understood when it is realized that there has actually been added to the soil a certain definite amount of nitrogen in such form that the wheat can be benefited by it. Such efficient users of the atmospheric nitrogen are clover and peas and similar crops that they can actually live and thrive in a soil that has not the first trace of combined nitrogen within it.

Inoculation.—Experiments showed that leguminous plants obtained nitrogen from some source and under conditions where it was not available for the nutrition of the cereals, and, eventually, that it was obtained from the atmosphere. It was suggested that the tubercles observed on the roots of leguminous plants had a direct relation to the appropriation of nitrogen, but most observers looked upon them as abnormal and of no physiological significance. The latest investigations, however, show beyond the shadow of a doubt that these tubercles or nodules are the result of infection by microbes and that the relation between the roots and the bacterial organisms is a true symbiotic one, each developing more vigorously at the expense of the other, and that free nitrogen is appropriated by the microbes.—(Y. B. 1902; Y. B. 1906; Va. Ex. Sta. B. 159.)

The tubercles or nodules on the roots of clovers, peas, etc., had been noticed for a considerable time (since 1687). Some thought they were of parasitic origin, and others saw in them simply excrescences or galls, and a few thought they were the normal growths of the plant; and it was not until 1886 that two German scientists, Hellriegel and Willfarth, showed that the development of the root nodules was intimately connected with the growth of the whole plant, and that the assimilation of the nitrogen of the atmosphere by legumes was associated with the development of the nodules or tubercles on the roots. Later investigators confirmed these results, and these discoveries were quickly followed by the detection of the bacteria in the nodules, their isolation and growth on artificially prepared food and the ability of these cultivated organisms to produce other nodules when brought into contact with suitable legumes growing in sterilized or germ free soil.

About 1902 the study of the root-nodule organism was undertaken by the Laboratory of Plant Physiology of the United States Department of Agriculture, and they perfected a method by which these organisms could be sent out to farmers and used for inoculating seed. Up to November, 1904, over 12,000 packages of inoculating material were distributed, and the reports of 3,540 experimenters showed that 79 per cent of these were successful. There are three methods of inoculating the crop:

(1) By transfer of soil; (2) by treating the soil; (3) by treating the seed. In the first case, soil which is known to contain the nodule-producing organisms is scattered over the land where it is desired to grow a crop of legumes. In other words, the land is top-dressed with soil from an infected field. This method has given good results, but is expensive when the soil has to be brought any distance, and in certain sections of the country such a practice is fraught with danger, as weed seeds and certain diseases are apt to

be transferred from one field to another by this means. In the second method, a quantity of soil is moistened with large quantities of culture, and this is mixed with more dry soil, and then used as a top dressing on the land that is to be planted. For small gardens, liquid cultures may be used and applied by means of a watering can to the young plants, but it is far better to have the bacteria on the seed so that the plant may become inoculated when they commence to grow. The third method, seed treatment, consists in moistening the seed with a culture or growth of the desirable bacteria, allowing the seed to dry for a short time and immediately sowing it. The latter is highly recommended.—(Del. Col. B. 40; Y. B. 1909; Ont. Agr. Dept. B. 148; Y. B. 1906.)

Anyone who has seen the great injury wrought by root nematodes, the wilt diseases of melons, cowpeas, tobacco, cotton, tomatoes, potatoes, flax, the black-rot of cabbage and cauliflower, the various stem and root diseases of clover and alfalfa, and diseases of other crops almost too numerous to mention, and widely distributed, will investigate carefully before importing soil that may contain the spores of these organisms. For the reasons above mentioned, pure-culture inoculation must eventually mainly replace the soil-transfer methods for all kinds of soil inoculation, but this has not yet been put on a practical basis for any except the nodule bacteria.

Artificial Cultures.—A number of years ago a German investigator conceived the idea that inoculation might be brought about by pure cultures grown in an artificial medium. Since that time extensive experiments as to the value of this inoculation have been conducted in all countries.

A cheap and thoroughly effective way of distributing and applying these organisms in general agricultural practice has been devised and put into use on a large scale. At a cost of a few cents a bushel, the seeds of clover, alfalfa, peas, beans, or any other legumes may be inoculated with these bacteria, thus making it possible to secure good crops on soils devoid of nitrogen, and at the same time leave a large quantity of this element fixed in the soil in a form available to wheat, corn, potatoes, or any other crop that may follow the legumes.

Since it is no longer questionable that the seeds of legumes can be inoculated with artificial cultures of nitrogen-fixing bacteria and large amounts of nitrogen gathered from the air and converted into forms, not only available for the growing crop but stored in the land for the use of future crops, it would be well to note the conditions under which the best results may be obtained. (1) On poor land that has not previously grown legumes; (2) on land that produces poor crops of legumes and where, upon examination, the roots fail to show the presence of nodules; (3) where the legume to be planted is of a widely different species to the ones previously planted on the land; (4) where the land has previously produced a lot of legumes, possessing nodules which, instead of being beneficial, acted as parasites. Good results may be obtained from the use of pure cultures when a field which has previously grown good crops of legumes begins to give evidence that, all other conditions being the same, it is not producing the highest yields. The cause may be that the bacteria already in the soil are losing their virulence, and the only way to be certain of this is to try inoculation and note results.

Since the only purpose in adding the bacteria to the soil is to furnish nitrogen to the plants in an available form, usually with root nodules, it is evident that where the organisms are already abundant and the crop is thriving, but little benefit can be expected from an additional inoculation. Neither is inoculation necessary where the soil is already very rich in nitrogen, nor where it is already full of nitrogen-fixing bacteria.

Inoculation Will Fail.—(1) When the directions for preparing the solution are not carefully followed; (2) when the soil is too acid or or too alkaline to permit the development of either plants or bacteria; (3) when the soil is deficient in other necessary plant foods, such as potash and phosphorus, as well as nitrogen. Above all things, it should be remembered that no inoculation will overcome poor results due to bad seed, improperly prepared seed beds, bad cultivation of land, weeds and grass, or adverse climatic conditions. Liming where needed and the addition of phosphatic and potash fertilizers should not be neglected.—(Y. B. 1902; Va. Ex. Sta. B. 159.)

BREEDING NITROGEN INTO FIELD CROPS.

There are few general considerations in the breeding of plants and animals which are more important than that of breeding a stronger tendency toward the production of nitrogen compounds. Protein is worth, on the average, about 4 cents per pound in those substances used for food for animals and man, while carbohydrates and fats, excepting in special forms, as in highly flavored butter, are worth much less. The farmer can produce starch, cellulose, and sugar in his staple field crops for a small fraction of 1 cent per pound, often a very small fraction. The carbonaceous substances contain neither nitrogen nor mineral fertilizing substances, and their use as plant food is limited to improving the water-holding power of the soil, and, upon decaying, furnishing active compounds which help to elaborate plant food from the insoluble mineral and nitrogen compounds in the soil.

On the other hand, the protein of our food plants, in addition to being very valuable as a food, is a most important fertilizer. In addition to its value of about 4 cents per pound as a food stuff, protein compounds are worth, at the commercial rate of nitrogen, about 2 cents per pound as fertilizers. Assuming that half of the nitrogen can be retained for fertilizer on the farm upon which the crops of grain and forage are grown and fed to animals, we have 1 cent per pound valuation of the protein in the foods we raise for our animals as a manure to add to its value of 4 cents per pound as a food for live stock. These values can not all be secured and realized by the farmer, because he sells some of his crops in the cities. We should seek to increase the yield of nitrogen per acre, as well as the total yield of crop, just as the breeders of sugar beets must increase the yield of beet sugar per acre rather than the tonnage of the roots, and the breeders of dairy cows increase the yield of butter rather than the yield of milk. Thus we should add to the protein content of our cereal and forage crops. In case of corn fodder there is a special reason for increasing the content of protein. The varieties of corn used for dry fodder or for silage already yield so well that a super-abundance of roughage can easily be produced. But to make it valuable as a balanced ration we must add to it expensive concentrated foods, such as bran, oil cake, or other grain products.

By increasing the percentage of protein in the fodder or silage a less amount of the expensive grain foods will be required, and, the ration being cheaper, will leave a larger margin of profit. But of even greater importance is the breeding up of the nitrogen content in clover, cowpeas, alfalfa, and other plants which gather nitrogen from the air. These crops should not only have their nitrogen content increased, but they should also be so bred as to succeed far better than now and under far wider ranges of conditions. Red clover, for instance, has been improved comparatively little since it was brought from Europe. It thrives well under some conditions, yet it does not meet all the difficulties and is not profitable in some localities where it should be made very useful. If it could be grown under conditions where it is not now hardy, its use as a fertilizing agent would be greatly extended, and if it were bred to extract still larger amounts of nitrogen from the air, it would be more valuable as a fertilizer and also as a food for domestic animals. Mr. W. T. Swingle proposes that the nitrogen-gathering bacteria associated with the nodules on the clover roots could also be bred so as to be more actively useful; and since brewers have successfully bred special varieties of brewing yeast for making beers of different qualities, the breeding of these bacteria would seem also to be a practical undertaking. The field pea, likewise, is a crop worthy of most serious effort, both that varieties may be secured which will produce profitable crops in localities where it is not now successfully grown, and that the contents of its seeds and its vines and leaves may have a larger percentage of this most valuable element, protein. Alfalfa, cowpeas, and soy beans, for like reasons, should be improved. These are the five principal nitrogen-producing plants of this country, each with its special very large field of usefulness. To change each plant so that its range of successful production would be enlarged 10 per cent, its protein content increased 10 per cent, and its yield increased 10 per cent where now grown, would cost only a very small fraction of the resulting increase in value. Increasing the protein content in this manner would in the aggregate be a very large increase of the nitrogen annually gathered from the air into the soil of the country. Since the sugar content in sugar beets has been so greatly increased, an increase of the protein of clover from 15 per cent of the dry matter to 16.5 per cent or even to 20 per cent should not be impracticable. But, important as may be the increase in nitrogen, breeding so as to adapt these crops to conditions where they now partially or wholly fail, and increasing their general yield and other good qualities in localities where they are now used, are the more important problems and probably should receive the first attention.

There is no reason why the nitrogen content of a variety can not be increased as well as the sugar content, the flavor, the hardiness, the height, or any other measurable characteristic. The Kansas Experiment Station found that ears of corn of a variety grown for thirty years on the same farm varied in protein content from 9 to 13 per cent, and that different varieties of corn varied about the same. Professor Hopkins, of the Illinois station, proved that corn plants with grain high in percentage of nitrogen generally produced grain with more nitrogen, thus proving that this quality can be improved.—(Div. Veg. Phys. B. 29.)

PART IV

HOME ECONOMICS AND EDUCATION.

HOME ECONOMICS.

THE subject of Home Economics may be treated under three main heads. (1) Food; (2) Shelter, and (3) Domestic Relations. Food is necessary to all animal life to build up the body and supply bodily heat and energy. It includes besides a study of the nourishment necessary in health and a further consideration of those food materials useful when bodily vigor is lacking, in convalescence or disease. Under this head comes also a study of remedial foods and medicinal drugs.

Shelter is necessary to protect the body from extremes of heat and cold, or the fury of the elements and thus to conserve the body heat and energy derived from food; and further to protect from disease. Under this head are considered problems of proper housing and, to a limited extent, proper clothing.

Domestic relations promote and conserve the happiness of individuals in life and their usefulness to their families and the community in general. Under this head such subjects as home culture, reading, recreation, children's needs, schooling and the broader community interests in reading clubs, good roads, telephone service and women's institutes are to be discussed.

FOOD AND ITS ELEMENTS.

The problem of proper nutrition has always been of great importance, yet scientific study of this subject is comparatively recent. Food investigations have been carried on in Europe for some three-quarters of a century, and for a less time in the United States and Canada. In recent years the development of this subject has been very rapid; a large number of investigations have been carried on under the auspices of the Department of Agriculture, the Agricultural Experiment Stations, and various educational institutions, and many facts of interest and importance have been learned. It seems desirable, therefore, to summarize this information, and, so far as possible, to interpret the results in such a way as to show their practical application. Constant use has made all so familiar with ordinary foods that they seldom realize how complicated they are; yet a thorough understanding of them takes each person far, not only into chemistry, but into physics and physiology as well.

Chemical Composition of the Body and of Food.—The chemical substances of which the body is composed are very similar to those of the foods which nourish it. They are made up of the same chemical elements, and hence the two may be discussed together. From fifteen to twenty elements are found, among the most abundant of which are oxygen, hydrogen, carbon, nitrogen, calcium, phosphorus, and sulphur. The elements are so combined as to form a great variety of compounds in both body and food. The most important kinds of compounds in the body and in foods are protein, fats, carbohydrates, mineral matter, and water. The functions of these compounds in the food are to build and repair the various tissues of the body and to supply it with heat and muscular energy.

Water.—Water is one of the most abundant of these compounds. It forms over 60 per cent of the weight of the average man, being a part of all the tissues. It is thus an important constituent of food, though it can not be burned, and hence does not yield energy to the body.

Mineral Matter or Ash.—Other food ingredients which yield little or no energy and are yet indispensable to the body are the mineral matters. They form only 5 or 6 per cent of the body by weight, and are found chiefly in the bones and teeth, but are present also in the other tissues and in solution in the various fluids. When food or body material is burned the mineral constituents remain as ash. Phosphate of lime, or calcium phosphate, is the mineral basis of bone. Numerous compounds of potassium, sodium, magnesium, and iron are found in the body and are necessary to life.

The remaining nutritive materials are organic compounds, so called because they occur principally in the organic, i. e., the animal and vegetable world. They all contain carbon, oxygen, and hydrogen, in varying proportions. Some also contain nitrogen, phosphorus, sulphur, or other elements. Those occurring in the body and in food are divided into three principal groups—protein, fats, and carbohydrates.

Protein.—This term includes the principal nitrogenous compounds—those containing nitrogen as one of the elements. Protein is familiar to us in the lean and gristle of meat, the white of eggs, the gluten of wheat, etc. It forms about 18 per cent, by weight, of the body of the average man. Protein compounds may be subdivided into albuminoids, gelatinoids, and extractives. The albuminoids include substances similar to the white of egg, the lean of meat, the curd of milk, and the gluten of wheat. The gelatinoids occur principally in the connective tissues, such as the collagen of the tendons and skin and the ossein of bone; from them is obtained gelatine.

The albuminoids and gelatinoids, classed together as proteids, are most important constituents of food. They make the basis of bone, muscle, and other tissues, and are essential to the body structure. They are also used as fuel—that is, they are burned in the body to yield energy—and they are to some extent transformed into fat and stored in the body, but these are their less important uses.

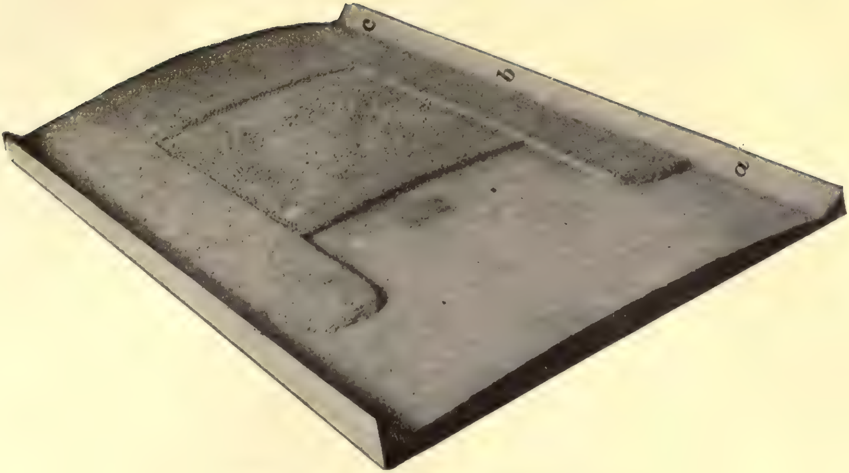
The protein compounds are most abundant in some of the animal foods, as lean meat, though the cereals contain them in considerable, and peas and beans in large proportions. The gelatinoids are less valuable than the albuminoids for nutriment.

The extractives are included with the protein compounds because they contain nitrogen, but they differ greatly from the albuminoids and gelatinoids. They are the principal ingredients of meat extracts, beef tea, etc. They are believed to neither build tissue nor furnish energy, but to act as stimulants and appetizers. The craving which some persons have for meat is perhaps due in part to a desire for these extractives. The nitrogenous compounds of potatoes and other vegetable foods contain substances similar to the extractives of meat, and like them can not build tissue, and hence have an inferior nutritive value.

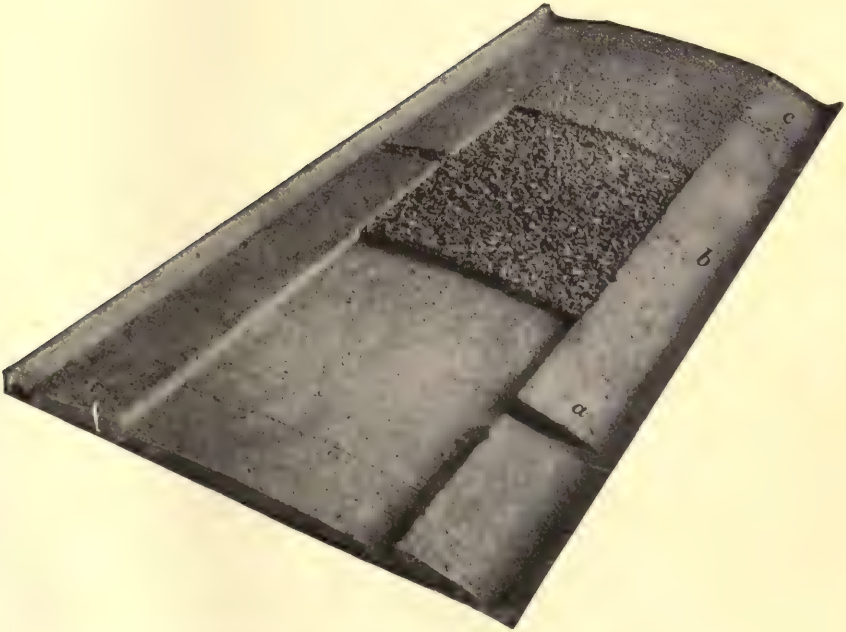
Fats.—Fats occur chiefly in animal foods, as meats, fish, butter, etc. They are also abundant in some vegetable products, such as olives and cotton seed, from which they are expressed as oil, and occur in considerable quantities in some cereals, notably oatmeal and maize (whole kernel), and in various nuts. In our bodies and those of animals fats occur in masses under the skin and in other localities, and in minute particles scattered through the various tissues. The amount of fat in the body varies greatly with food, exercise, age, and other conditions. When more food is taken than is necessary for immediate use part of the surplus may be stored in the body. The protein and fat of food may thus become body protein and body fat; sugar and starch of food are changed to fat in the body and stored as such. When the food supply is short this reserve material is drawn upon for fuel. Fat forms about 15 per cent, by weight, of the body of an average man.

Carbohydrates.—These are so called because they contain both carbon and hydrogen. They include such compounds as starches, different kinds of sugar, and the fiber of plants or cellulose. They are found chiefly in the vegetable foods, like cereal grains and pototoes; milk, however, contains considerable amounts of milk sugar, which is carbohydrate. The carbohydrates form only a very small proportion of the body tissues—less than 1 per cent. Starches and sugars, which are very abundant in ordinary food materials, are important food ingredients, because they form an abundant source of energy and are easily digested. They may be and often are transformed into fat in the body.

Refuse.—Food, as bought at the market or even as it is served on the table, contains more or less of materials which can not be or is not eaten, such as the bones of meat and fish, the shells of eggs, and the skins and seeds of fruits and vegetables. In discussing the chemical composition of foods such portions are usually counted as refuse, but they make an important item when the actual cost of the nutrients of food is considered. Refuse contains in part, the same ingredients as the edible portion, though usually in very different



Model of Gravel Road. Dept. of Agr.
(See pages 149-165.)



Model of Macadam Road. Dept. of Agr.

proportions. In some cases material which is edible is classed as refuse because the flavor is objectionable, as peach and plum pits commonly thought to be actually injurious.

FOOD AS BUILDING MATERIAL AND FUEL.

Blood and muscle, bone and tendon, brain and nerve—all the organs and tissues of the body—are built from the nutritive ingredients of food. With every motion of the body and with the exercise of feeling and thought as well, material is consumed and must be resupplied by food. In a sense, the body is a superior machine. Like other machines, it requires material to build up its several parts, to repair them as they are worn out, and to serve as fuel. The steam engine gets its power from fuel; the body does the same. In the one case coal or wood, in the other food, is the fuel. In both cases the energy which is hidden in the fuel—the potential energy, as it is called in scientific language—is transformed into power and heat.

From the time foods are taken into the body until they are digested, absorbed, utilized, and finally converted largely into the carbon dioxid and water vapor of the breath and the nitrogenous and other excretory products of the urine and feces, they undergo great chemical changes, very many of which liberate heat as a result of oxidation or some closely related process. It is through these complex chemical processes that the body derives the energy for internal and external muscular work. Heat is evolved by such chemical changes and also results from the muscular work of the body.

The amount of heat produced in the body must, of course, vary with the amount of food eaten, the work done, and other circumstances. However, the body is such a perfect piece of mechanism that the loss of heat by radiation, etc., is so adjusted to heat production that body temperature remains fairly constant. In the use of its source of power the body is much more economical than any engine. But the body is more than a machine. It has not simply organs to build and keep in repair and supply with energy; it has a nervous organization; it has sensibilities; and there are the higher intellectual and spiritual faculties. The right exercise of these depends upon the right nutrition of the body.

The chief uses of food, then, are two: (1) To form the material of the body and repair its wastes, and (2) to furnish muscular and other power for the work the body has to do and yield heat to keep the body warm. In forming the tissues and the fluids of the body the food serves for building and repair. In yielding power and heat it serves as fuel. If more food is eaten than is needed, more or less of the surplus may be and sometimes is stored in the body, chiefly in the form of fat. When the work is hard or the food supply is low the body draws upon this store of fat and grows lean.

Protein a Building Material.—The principal tissue formers are the protein compounds, especially the albuminoids. These make the framework of the body. They build up and repair the nitrogeneous materials, as the muscles and tendons, and supply the albuminoids of the blood, milk, and other fluids.

The albuminoids of food are transformed into the albuminoids and gelatinoids of the body. Muscle, tendon and cartilage, bone and skin, the corpuscles of the blood, and the casein of milk are made of the albuminoids of food. The albuminoids are sometimes called "flesh formers" or "muscle formers," because the lean flesh, the muscle, is made from them, though the term is inadequate as it leaves out of account the energy-furnishing function of protein. The gelatinoids of food, such as the finer particles of tendon and the gelatin, which are dissolved out of bone and meat in soup, though somewhat similar to the albuminoids in composition, are not believed to be tissue formers. They are valuable in protecting the albuminoids from consumption. The proteids can be so changed in the body as to yield fats and carbohydrates, and such changes actually occur to some extent.

Protein as Fuel for the Body.—The protein compounds are also burned directly in the body like the carbohydrates, and thus render important service as fuel. A man can live on lean meat. He can convert its material into muscle and its energy into heat and muscular power, but such a one-sided diet would not be best.

Fats and Carbohydrates as Fuel.—Fats and carbohydrates are the chief fuel ingredients of food. Sugar and the starch of bread and potatoes are burned in the body to yield heat and power. The fats, such as the fat of meat and butter, serve the same purpose, only they are a more concentrated fuel than the carbohydrates. The body can also transform carbohydrates of food into fat. The different nutrients can to a greater or less extent do one another's work. If the body has not enough of one kind of fuel it can use another. But, while protein can be burned in the place of fats and carbohydrates, neither of the latter can take the place of the albuminoids of protein in building and repairing the tissues.

VALUE OF FOOD FOR SUPPLYING ENERGY.

Heat and muscular power are forms of force or energy. The energy latent or hidden in the food is developed as the food is consumed in the body. The process is more or less akin to that which takes place when coal is burned in the furnace of the locomotive. For the burning of the food in the body or the coal in the furnace, air is used to supply oxygen. When the fuel is oxidized or burned be it meat or wood, bread or coal, the latent energy becomes active, is transformed into power and heat. As various kinds of coal differ in the amount of heat given off per ton, so various kinds of food differ in amounts of energy.

The processes of oxidation burning of material and transformation of energy in the body are less simple than in the engine and less clearly understood. Late research, however, has given ways of measuring the energy latent in coal, wood, and in food materials as well. The amount of heat given off in the oxidation of a given quantity of any material is called its "heat of combustion," and is taken as a measure of its latent or potential energy. The unit commonly used is the calorie, the amount of heat which would raise the temperature of 1 kilogram of water 1° Centigrade, or 1 pound of water 4° Fahrenheit. Instead of this unit of heat a unit of mechanical energy may be used—for instance, the foot-ton, which represents the force required to raise 1 ton 1 foot. One calorie is equal to very nearly 1.54 foot-tons; that is to say, 1 calorie of heat, when transformed into mechanical power, would suffice to lift 1 ton 1.54 feet.

The Conservation of Energy in the Body.—The amounts of energy transformed in the body when food and its own material are burned within it are measured with the respiration calorimeter. Food is not completely oxidized in the body. Experiments have shown that the material which is oxidized yields the same amount of energy as it would if burned with oxygen outside the body. The experiments show also that when a man does no muscular work (save, of course, the internal work of respiration, circulation, etc.), all the energy leaves his body as heat; but when he does muscular work, as in lifting weights or driving a bicycle, part of the energy appears in the external work thus done, and the rest is given off from the body as heat. The energy given off from the body as heat when the man is at rest, or as heat and mechanical work together when he is working, exactly equals the latent energy of the material burned in the body. This is in accordance with the law of the conservation of energy which dominates the physical universe.

The fuel value of protein is 4 calories per gram or 1820 calories per pound. The fuel value of fats is 9 calories per gram or 440 calories per pound. The fuel value of carbohydrates is 4 calories per gram or the same as that for protein. So a pound of protein of lean meat or albumen of eggs is just about equivalent to a pound of sugar or starch, and a little over 2 pounds of either would be required to equal a pound of the fat of meat or butter or of body fat. Fat is the most concentrated form of body fuel. There has thus far been considered food only as a source of heat and muscular power. There is no doubt that intellectual activity, also, is somehow dependent upon the consumption of material which the brain has obtained from the food, but concerning this humanity does not know it all yet.—(Dept. Agr. F. B. 142.)

FUNCTIONS AND NUTRITIVE VALUE OF FOOD.

The principles above explained are based upon a great deal of experimentation and observation, but of especial importance is the work with the respiration (breathing out) apparatus and respiration calorimeter. These will be described later. With such apparatus it is possible to learn what effect different conditions of nourishment will have on the body.

FOOD AND FOOD ECONOMY.

What has thus far been said about the ingredients of food and the ways they are used in the body may be briefly summarized in the following manner:

Nutritive Ingredients (or Nutrients) of Food.

Food as purchased contains—
- Edible portion
  e. g., flesh of meat, yolk and white of eggs, wheat flour, etc.
  - Water.
  - Nutrients
    - Protein.
    - Fats.
    - Carbohydrates.
    - Mineral matters.
- Refuse.
  e. g., bones, entrails, shells, bran, etc.

Uses of Nutrients in the Body.

Protein e. g., white (albumen) of eggs, curd (casein) of milk, lean meat, gluten of wheat, etc.	Forms tissue	All serve as fuel to yield energy in the forms of heat and muscular power.
Fats e. g., fat of meat, butter, olive oil, oils of corn and wheat, etc.	Are stored as fat	
Carbohydrates e. g., sugar, starch, etc.	Are transformed into fat	
Mineral matters (ash) e. g., phosphates of lime, potash, soda, etc.	Share in forming bone, assist in digestion, etc.	

The views thus presented lead to the following definitions: (1) Food is that which, taken into the body, builds tissues or yields energy; (2) the most healthful food is that which is best fitted to the needs of the user; (3) the cheapest food is that which furnishes the largest amount of nutriment at the least cost; and (4) the best food is that which is both most healthful and cheapest.

There are then to consider the kinds and amounts of nutrients in different food materials, their digestibility, the kinds and amounts needed for nourishment by persons under different conditions of rest and work, and the nutritive value of different food products as compared with their cost.—(Dept. Agr. F. B. 142.)

SOURCES OF FOOD.

Considering now the sources of the food supply it is found that every kingdom of nature—the vegetable, the animal, and the mineral yield something of value. From the vegetable kingdom are obtained the cereals wheat, oats, rye, corn, rice, peas, beans and other legumes; table vegetables such as potatoes, turnips, onions, cabbages and squashes; vegetable oils such as cotton seed, olive and peanut; sugar from sugar cane, sugar beets, maple trees; honey, which although derived from flowers and fruits is manufactured by humanity's busy little friend and may be classed as either of vegetable or animal origin; fruits both fresh and dried; nuts; and lastly, beverages, such as tea, coffee, cocoa, fruit juices, cider and wines. Animal food, in its initial form, is the flesh of such animals as are accounted suitable, the domestic cattle, swine, sheep, goats, poultry, fish, and wild animals or game. Part of these animals are maintained for their service as producers of milk or producers of eggs, a service which ends when they are converted to meat. The fresh milk of cows and the eggs of poultry may be classified as secondary products. The milk manufactured into butter and cheese becomes a product yet another remove from the initial, and eggs are so prominently familiar in daily supplies that many forget their secondary relation to the animals that furnish them. In a less emphatic way butter and cheese, from time immemorial, have been closely associated with the household care of milk as if they were primary supplies. Under the head of fish are classed fish, mollusca (oysters, clams, etc.), crustaceans (lobsters, crabs, shrimp) and reptiles (turtles being the most important).

The minerals used by the body are not energy producers, but are as necessary to life. Chief among those collected or manufactured for human food are salt and to a more limited extent soda. The latter is not ordinarily used for its physiological effect but for its mechanical and chemical effect, as when it combines with an acid and gives off gas, which causes bread or cake to become porous and light and so more digestible and palatable as a food. Other minerals are largely derived from organic sources, that is from animal or vegetable foods. Except as medicines, compounds of iron, sulphur, magnesium, phosphorus and other minerals are seldom, if ever, taken in inorganic form.—(Dept. Agr. Bul. 142; Div. of Stat. Bul. 24.)

NUTRITIVE VALUE OF FOOD.

How Learned.—In order to learn definitely the nutritive value of any food and the energy to be obtained by its use, it is necessary to consider not only its chemical composition but the availability of these elements for the body under different conditions. For instance, dried beans contain 22.5% protein and 59.6% carbohydrates, but when the amounts of digestible nutrients are considered it is found that only 17.5% protein and 57.8% carbohydrates are available for body use. Over one-fifth of the protein is not digested and so is lost. So a great many experiments concerning the metabolism of matter and energy in the human body have been made. By metabolism is meant the chemical and physical changes which take place within the body when food is digested and transferred into living tissue of various kinds. Metabolism is the general term given to these changes. The metabolism of food means the changes which the food undergoes within the body and the metabolic products are those new products formed by these chemical and physical changes. Examples of such chemical changes are the transforming of insoluble starch of food into a soluble sugar by the action of the saliva in the mouth, the action of the digestive juices of the stomach and intestines on the various foods, breaking them up into other compounds to be absorbed and used by the various parts of the body, and the further changes that they undergo in the different organs of the body as the liver and kidneys. Examples of physical changes are the transformation of the latent heat of fats and foods into body heat or into muscular work or energy.

The ultimate purpose of the research to which such experiments belong is the study of some of the fundamental laws of nutrition. The plan of the present inquiry is based upon the principle that the chemical and physical changes which take place within the body occur in obedience to the laws of the conservation of matter and energy. That the law of the conservation of matter applies within the living organism no one would question. It might seem equally certain that the metabolism of energy within the body takes place in accordance with the law of the conservation of energy. The quantitative demonstration is, however, desirable, and an attested method for such demonstration is of fundamental importance for the study of the general laws of metabolism of both matter and energy.

Since, furthermore, the main use of food is to supply material and energy for nourishment, this inquiry has to do with the values and uses of foods. Taken all together, therefore, we may say that while the more scientific object of the research is a study of the laws of nutrition, in so far as they are laws of metabolism of matter and energy, the practical purpose is to learn more about how the body is nourished and what are the uses and values of food.

Apparatus.—For this study expensive and complicated apparatus is necessary and the time used is proportionately great. Investigations have been made in many ways but those of most importance have been by means of the respiration apparatus and the respiration calorimeter.

Various forms of respiration apparatus have been devised within the last fifty years. They consist of metal-walled chambers large enough for the subject (sometimes a man, sometimes a dog, sheep, or other animal) to live in comfortably for several days, and are furnished with devices for pumping air through and measuring and analyzing it as it enters and leaves the chamber. With such an apparatus it is possible not only to measure all the food and excreta, but also the materials given off from the lungs in the breath, and to make accurate determinations of the matter entering and leaving the body.

A still more elaborate apparatus, by which not only all the matter passing in and out of the body may be measured, but also all the heat given off from it, is called a respiration calorimeter. It is like the respiration apparatus, except that it is furnished with devices for measuring temperatures. Its main feature is a copper walled chamber in which the subject of the experiment—a man—lives, eats, drinks, sleeps, and works during a period of several days and nights. This is fitted with devices for maintaining and measuring a ventilating current of air, for sampling and analyzing this air, for removing and measuring the heat given off within the chamber, and for passing food and other articles in and out. It is furnished with a folding bed, chair, and table, with scales and with appliances for muscular work, and has telephone connection with the outside. Here the subject stays for a period of from three to twelve days, during which time careful analyses and measurements are made of all material which enters the body in the food and of that which leaves it in the breath and excreta. Record is also kept of the energy given off from the body as heat and muscular work. The differences between the material taken into and that given off from the body is called the balance of matter, and shows whether the body is gaining or losing material. The difference between the energy of the food taken and that of the excreta and the energy given off from the body as heat and muscular work, is the balance of energy, and if correctly estimated should equal the energy of the body material gained or lost.

With such apparatus it is possible to learn what effect different conditions of nourishment will have on the human body. In one experiment, for instance, the subject might be kept quite at rest, and in the next do a certain amount of muscular or mental work, with the same diet as before. Then by comparing the results of the two the use which the body makes of its food under the different conditions could be determined. Or the diet may be slightly changed in one experiment and the effect of this on the balance of matter and energy observed. Such methods and apparatus are very costly in time and money, but the results are proportionately more valuable than those from similar experiments.—(Dept. Agr. F. B. 142; Dept. Agr. Off. of Exp. St. Buls. 17, 66, 69, 109, 123, 136.)

CHEMICAL COMPOSITION OF FOOD.

The value of food for nutriment depends mainly upon its composition and digestibility. The composition of foods is determined by chemical analysis. The first effective impulse to the systematic study of the chemistry of foods was given by Liebig somewhat over 50 years ago, but nearly all of our definite knowledge of the chemical composition of food materials has accumulated within comparatively a few years past.

Until about the year 1880 most of the food analyses had been made in German laboratories and during the last two decades, the results of over 4,000 analyses of food materials from different parts of the United States are available. A large proportion of these analyses have been made during the last few years in connection with nutrition investigations under the auspices of the Department of Agriculture.

Table I shows the average composition of ordinary American food materials as calculated from the analyses now available. The value of food as influenced by digestibility is discussed later.

TABLE I.—*Average Composition of Common American Food Products.*

Food Materials (as purchased).	Refuse.	Water.	Protein.	Fat.	Carbohydrates.	Ash.	Fuel value per lb.
ANIMAL FOOD.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Beef, Fresh:							
Chuck ribs	16.3	52.6	15.5	15.0	....	0.8	910
Flank	10.2	54.0	17.0	19.0	....	.7	1.105
Loin	13.3	52.5	16.1	17.5	....	.9	1,025
Porterhouse steak	12.7	52.4	19.1	17.9	....	.8	1,100
Sirloin steak	12.8	54.0	16.5	16.1	....	.9	975
Neck	27.6	45.9	14.5	11.9	....	.7	1,165
Ribs	20.8	43.8	13.9	21.2	....	.7	1.135
Rib rolls	....	63.9	19.3	16.7	....	.9	1,055
Round	7.2	60.7	19.0	12.8	....	1.0	890
Rump	20.7	45.0	13.8	20.2	....	.7	1,090
Shank, fore	36.9	42.9	12.8	7.3	....	.6	545
Shoulder and clod	16.4	56.8	16.4	9.8	....	.9	715
Fore quarter	18.7	49.1	14.5	17.5	....	.7	995
Hind quarter	15.7	50.4	15.4	18.3	....	.7	1,045
Beef, corned, canned, pickled, and dried:							
Corned beef	8.4	49.2	14.3	23.8	....	4.6	1,245
Tongue, pickled	6.0	58.9	11.9	19.2	....	4.3	1,010
Dried, salted, and smoked	4.7	53.7	26.4	6.9	....	8.9	790
Canned boiled beef	....	51.8	25.5	22.5	....	1.3	1,410
Canned corned beef	....	51.8	26.3	18.7	....	4.0	1,270
Veal:							
Breast	21.3	52.0	15.4	11.0	....	.8	745
Leg	14.2	60.1	15.5	7.9	....	.9	625
Leg cutlets	3.4	68.3	20.1	7.5	....	1.0	695
Fore quarter	24.5	54.2	15.1	6.0	....	.7	535
Hind quarter	20.7	56.2	16.2	6.6	....	.8	580
Mutton:							
Flank	9.9	39.0	13.8	36.9	....	.6	1,770
Leg, hind	18.4	51.2	15.1	14.7	....	.8	890
Loin chops	16.0	42.0	13.5	28.3	....	.7	1,415
Fore quarter	21.2	41.6	12.3	24.5	....	.7	1,235
Hind quarter, without tallow	17.2	45.4	13.8	23.2	....	.7	1,210
Lamb:							
Breast	19.1	45.5	15.4	19.1	....	.8	1.075
Leg, hind	17.4	52.9	15.9	13.6	....	.9	864
Pork, fresh:							
Ham	10.7	48.0	13.5	25.9	....	.8	1,320
Loin chops	19.7	41.8	13.4	24.2	....	.8	1,245
Shoulder	12.4	44.9	12.0	29.8	....	.7	1,450
Tenderloin	....	66.5	18.9	13.0	....	1.0	895
Pork, salted, cured and pickled:							
Ham, smoked	13.6	34.8	14.2	33.4	....	4.2	1,635
Shoulder, smoked	18.2	36.8	13.0	26.6	....	5.5	1,335
Salt pork	....	7.9	1.9	86.2	....	3.9	3,555
Bacon, smoked	7.7	17.4	9.1	62.2	....	4.1	2,715
Sausage:							
Bologna	3.3	55.2	18.2	19.7	....	3.8	1.155
Pork	....	39.8	13.0	44.2	1.1	2.2	2,075
Frankfort	....	57.2	19.6	18.6	1.1	3.4	1,155
Soups:							
Celery, cream of	....	88.6	2.1	2.8	5.0	1.5	235
Beef	....	92.9	4.4	.4	1.1	1.2	120
Meat stew	....	84.5	4.6	4.3	5.5	1.1	365
Tomato	....	90.0	1.8	1.1	5.6	1.5	185
Poultry:							
Chicken, broilers	41.6	43.7	12.8	1.4	....	.7	305
Fowls	25.9	47.1	13.7	12.3	....	.7	765
Goose	17.6	38.5	13.4	29.8	....	.7	1,475
Turkey	22.7	42.4	16.1	18.4	....	.8	1,060
Fish:							
Cod, dressed	29.9	58.5	11.1	.2	....	.8	220
Halibut, steaks or sections	17.7	61.9	15.3	4.4	....	.9	475
Mackerel, whole	44.7	40.4	10.2	4.2	....	.7	370
Perch, yellow, dressed	35.1	50.7	12.8	.7	....	.9	275
Shad, whole	50.1	35.2	9.4	4.8	....	.7	380
Shad roe	....	71.2	20.9	3.8	2.6	1.5	600
Fish, preserved:							
Cod, salt	24.9	40.2	16.0	.4	....	18.5	325
Herring, smoked	44.4	19.2	20.5	8.8	....	7.4	755
Fish, canned:							
Salmon	....	63.5	21.8	12.1	....	2.6	915
Sardines	*a*5.0	53.6	23.7	12.1	....	5.3	950
Shellfish:							
Oysters, "solids"	....	88.3	6.0	1.3	3.3	1.1	225
Clams	....	80.8	10.6	1.1	5.2	2.3	340
Crabs	52.4	36.7	7.9	.9	.6	1.5	200
Lobsters	61.7	30.7	5.9	.7	.2	.8	145

a Refuse, oil.

TABLE I.—Continued.

Food materials (as purchased).	Refuse.	Water.	Protein.	Fat.	Carbohydrates.	Ash.	Fuel value per pound.
ANIMAL FOOD—continued.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Eggs: Hens' eggs	*a*11.2	65.5	13.1	9.3		0.9	635
Dairy products, etc.:							
Butter		11.0	1.0	85.0		3.0	3,410
Whole milk		87.0	3.3	4.0	5.0	.7	310
Skim milk		90.5	3.4	.3	5.1	.7	165
Buttermilk		91.0	3.0	.5	4.8	.7	165
Condensed milk		26.9	8.8	8.3	54.1	1.9	1,430
Cream		74.0	2.5	18.5	4.5	.5	865
Cheese, Cheddar		27.4	27.7	36.8	4.1	4.0	2,075
Cheese, full cream		34.2	25.9	33.7	2.4	3.8	1,885
VEGETABLE FOOD.							
Flour, meal, etc.:							
Entire-wheat flour		11.4	13.8	1.9	71.9	1.0	1,650
Graham flour		11.3	13.3	2.2	71.4	1.8	1,645
Wheat flour, patent roller process—							
High-grade and medium		12.0	11.4	1.0	75.1	.5	1,635
Low grade		12.0	14.0	1.9	71.2	.9	1,640
Macaroni, vermicelli, etc.		10.3	13.4	.9	74.1	1.3	1,645
Wheat breakfast food		9.6	12.1	1.8	75.2	1.3	1,680
Buckwheat flour		13.6	6.4	1.2	77.9	.9	1,605
Rye flour		12.9	6.8	.9	78.7	.7	1,620
Corn meal		12.5	9.2	1.9	75.4	1.0	1,635
Oat breakfast food		7.7	16.7	7.3	66.2	2.1	1,800
Rice		12.3	8.0	.3	79.0	.4	1,620
Tapioca		11.4	.4	.1	88.0	.1	1,650
Starch					90.0		1,675
Bread, pastry, etc.:							
White bread		35.3	9.2	1.3	53.1	1.1	1,200
Brown bread		43.6	5.4	1.8	47.1	2.1	1,040
Graham bread		35.7	8.9	1.8	52.1	1.5	1,195
Whole-wheat bread		38.4	9.7	.9	49.7	1.3	1,130
Rye bread		35.7	9.0	.6	53.2	1.5	1,170
Cake		19.9	6.3	9.0	63.3	1.5	1,630
Cream crackers		6.8	9.7	12.1	69.7	1.7	1,925
Oyster crackers		4.8	11.3	10.5	70.5	2.9	1,910
Soda crackers		5.9	9.8	9.1	73.1	2.1	1,875
Sugars, etc.:							
Molasses					70.0		1,225
Candy *b*					96.0		1,680
Honey					81.0		1,420
Sugar, granulated					100.0		1,750
Maple sirup					71.4		1,250
Vegetables: *c*							
Beans, dried		12.6	22.5	1.8	59.6	3.5	1,520
Beans, Lima, shelled		68.5	7.1	.7	22.0	1.7	540
Beans, string	7.0	83.0	2.1	.3	6.9	.7	170
Beets	20.0	70.0	1.3	.1	7.7	.9	160
Cabbage	15.0	77.7	1.4	.2	4.8	.9	115
Celery	20.0	75.6	.9	.1	2.6	.8	65
Corn, green (sweet) edible portion		75.4	3.1	1.1	19.7	.7	440
Cucumbers	15.0	81.1	7.0	.2	2.6	.4	65
Lettuce	15.0	80.5	1.0	.2	2.5	.8	65
Mushrooms		88.1	3.5	.4	6.8	1.2	185
Onions	10.0	78.9	1.4	.3	8.9	.5	190
Parsnips	20.0	66.4	1.3	.4	10.8	1.1	230
Peas (*Pisum sativum*), dried		9.5	24.6	1.0	62.0	2.9	1,565
Peas (*Pisum sativum*), shelled		74.6	7.0	.5	16.9	1.0	440
Cowpeas, dried		13.0	21.4	1.4	60.8	3.4	1,505
Potatoes	20.0	62.6	1.8	.1	14.7	.8	295
Rhubarb	40.0	56.6	.4	.4	2.2	.4	60
Sweet Potatoes	20.0	55.2	1.4	.6	21.9	.9	440
Spinach		92.3	2.1	.3	3.2	2.1	95
Squash	50.0	44.2	.7	.2	4.5	.4	100
Tomatoes		94.3	.9	.4	3.9	.5	100
Turnips	30.0	62.7	.9	.1	5.7	.6	120
Vegetables, canned:							
Baked beans		68.9	6.9	2.5	19.6	2.1	555
Peas (*Pisum sativum*), green		85.3	3.6	.2	9.8	1.1	235
Corn, green		76.1	2.8	1.2	19.0	.9	430
Succotash		75.9	3.6	1.0	18.6	.9	425
Tomatoes		94.0	1.2	.2	4.0	.6	95

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[a] Refuse, shell. [b] Plain confectionery not containing nuts, fruit or chocolate.

[c] Such vegetables as potatoes, squash, beets, etc., have a certain amount of inedible material, skin, seeds, etc. The amount varies with the method of preparing the vegetables, and can not be accurately estimated. The figures given for refuse of vegetables, fruits, etc., are assumed to represent approximately the amount of refuse in these foods as ordinarily prepared.

TABLE I.—Continued.

Food materials (as purchased).	Refuse.	Water.	Protein.	Fat.	Carbohydrates.	Ash.	Fuel value per pound.
VEGETABLE FOOD—continued.							
Fruits, berries, etc., fresh: *a*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Apples	25.0	63.3	0.3	0.3	10.8	0.3	190
Bananas	35.0	48.9	.8	.4	14.3	.6	260
Grapes	25.0	58.0	1.0	1.2	14.4	.4	295
Lemons	30.0	62.5	.7	.5	5.9	.4	125
Muskmelons	50.0	44.8	.3	....	4.6	.3	80
Oranges	27.0	63.4	.6	.1	8.5	.4	150
Pears	10.0	76.0	.5	.4	12.7	.4	230
Persimmons, edible portion	....	66.1	.8	.7	31.5	.9	550
Raspberries	....	85.8	1.0	....	12.6	.6	220
Strawberries	5.0	85.9	.9	.6	7.0	.6	150
Watermelons	59.4	37.5	.2	.1	2.7	.1	50
Fruits, dried:							
Apples	....	28.1	1.6	2.2	66.1	2.0	1,185
Apricots	....	29.4	4.7	1.0	62.5	2.4	1,125
Dates	10.0	13.8	1.9	2.5	70.6	1.2	1,275
Figs	....	18.8	4.3	.3	74.2	2.4	1,280
Raisins	10.0	13.1	2.3	3.0	68.5	3.1	1,265
Nuts:							
Almonds	45.0	2.7	11.5	30.2	9.5	1.1	1,515
Brazil nuts	49.6	2.6	8.6	33.7	3.5	2.0	1,485
Butternuts	86.4	.6	3.8	8.3	.5	.4	385
Chestnuts, fresh	16.0	37.8	5.2	4.5	35.4	1.1	915
Chestnuts, dried	24.0	4.5	8.1	5.3	56.4	1.7	1,385
Cocoanuts	*b* 48.8	7.2	2.9	25.9	14.3	.9	1,295
Cocoanut, prepared	....	3.5	6.3	57.4	31.5	1.3	2,865
Filberts	52.1	1.8	7.5	31.3	6.2	1.1	1,430
Hickory nuts	62.2	1.4	5.8	25.5	4.3	.8	1,145
Pecans, polished	53.2	1.4	5.2	33.3	6.2	.7	1,465
Peanuts	24.5	6.9	19.5	29.1	18.5	1.5	1,775
Pinon (*Pinus edulis*)	40.6	2.0	8.7	36.8	10.2	1.7	1,730
Walnuts, black	74.1	.6	7.2	14.6	3.0	.5	730
Walnuts, English	58.1	1.0	6.9	26.6	6.8	.6	1,250
Miscellaneous:							
Chocolate	....	5.9	12.9	48.7	30.3	2.2	2,625
Cocoa, powdered	....	4.6	21.6	28.9	37.7	7.2	2,160
Cereal coffee, infusion (1 part boiled in 20 parts water) *c*	....	98.2	.2	....	1.4	.2	30

a Fruits contain a certain proportion of inedible materials, as skin, seeds, etc., which are properly classed as refuse. In some fruits, as oranges and prunes, the amount rejected in eating is practically the same as refuse. In others, as apples and pears, more or less of the edible material is ordinarily rejected with the skin and seeds and other inedible portions. The edible material which is thus thrown away, and should properly be classed with the waste, is here classed with the refuse The figures for refuse here given represent, as nearly as can be ascertained, the quantities ordinarily rejected.

b Milk and shell.

c The average of five analyses of cereal coffee grain is: Water, 6.2, protein, 13.3, fat 3.4, carbohydrates 72.6, and ash 4.5 per cent. Only a portion of the nutrients, however, enter into the infusion. The average in the table represents the available nutrients in the beverage. Infusions of genuine coffee and of tea like the above contain practically no nutrients.

PROPORTIONS OF NON-NUTRIENTS IN FOODS.

It will be interesting to note some of the differences in food materials as shown by their composition. One of the first things which may be observed when a table like the above is studied, is the differences in the proportions of non-nutrients, i. e., refuse and water. Many kinds of food as they are purchased contain large amounts of refuse, which necessarily lessen the proportion of nutrients. Such refuse is usually absent in the dairy products (milk, butter, cheese, etc.), dried vegetables, cereal foods (flour, breakfast foods, etc.), and the bread, cakes, and other foods prepared from them. In considering the edible portion we find that the amount of water present also affects the nutritive value of food. Water is necessary to the body, but it is usually supplied in abundance by beverages. Water forms from 40 to 50 per cent of the ordinary cuts of meat, 10 to 12 per cent of dried seeds, grains and foods prepared from them, and 80 to 90 per cent of vegetables and fruits. Many cooked foods contain more water than the raw material due to the manner of cooking them. Compare flour and bread in the above table. In baked, roasted or fried meat the amount of water is diminished in cooking.

The most important of the actual nutrients has been seen to be protein. This occurs most abundantly in animal foods—meat, fish, eggs, and dairy products, and in the dried legumes, as beans and peas. Protein forms 14 to 26 per cent of meats, 28 to 38 per cent of cheese, 18 to 25 per cent of dried legumes and from 7 to 15 per cent of the cereals. Fruits contain only from less than 1 to 5 per cent of protein. Wheat flour has 11 per cent and bread 9 per cent, the decrease being due to the water added in bread making. Fat forms from 10 to 40 per cent of meat, over 80 per cent of salt pork, 85 per cent of butter, 25 to 40 per cent of cheese and 10 to 50 per cent of nuts. Carbohydrates form 5 per cent of milk, 70 to 80 per cent of cereals, 60 to 70 per cent of dried legumes and the bulk of the nutrients of vegetables. Mineral matters occur in all the ordinary foods one per cent or less in meats, from 0.3 to over 2 per cent in cereals and from 3 to 4 per cent in dried legumes.

In brief, then, it may be said that meats, fish, eggs, milk, fresh vegetables, and fruits contain the most refuse and water; that protein is most abundant in the animal foods and in the legumes and occurs in considerable quantities in the cereals; that fats occur principally in the animal foods; that carbohydrates are found almost exclusively in the vegetable product and milk; and that small quantities of mineral matters are found in all food materials. The fuel value varies within wide limits, being greatest in those materials which contain the most fat and the least water.

DIGESTION, ASSIMILATION, AND EXCRETION.

We live not upon what we eat, but upon what we digest. Food as we buy it in the market, or even as we eat it, is not usually in condition to be made into body structure or used as body fuel. It must first go through a series of chemical changes by what is called digestion, which prepare it to be absorbed, taken into the blood and lymph, and carried to the parts of the body where it is needed. Digestion takes place in the alimentary canal, partly in the stomach, but more in the intestine. As the result, the useless portions are separated and rejected, while the parts which can serve for nutriment are changed into forms in which they can be absorbed, taken into the circulation, and utilized.

Digestion.—The alterations which the food undergoes in digestion are brought about by substances called ferments, which are secreted by the digestive organs. The saliva in the mouth has the power of changing insoluble starches into soluble sugar, and helps to fit the food to be more easily worked on by the stomach. The gastric juice of the stomach acts upon protein, and the pancreatic juice of the intestine upon protein, fats, and carbohydrates. The action of all the ferments is aided by the fine division of the food by chewing and by the muscular contractions, the so-called peristaltic action, of the stomach and intestine. These latter motions help to mix the digestive juices and their ferments with the food.

The parts of the food which the digestive juices can not dissolve, and which therefore escape digestion, are periodically given off by the intestine. Such solid excreta, or feces, include not only the particles of undigested food, but also the so-called metabolic products, i. e., residues of the digestive juices, bits of the lining of the alimentary canal, etc.

Absorption and Assimilation.—The digested food finds its way through the walls of the alimentary canal, and at this time and later it undergoes remarkable chemical changes. When finally the blood, supplied with the nutrients of the digested food and freighted with oxygen from the lungs, is pumped from the heart all over the body it is ready to furnish the organs and tissues with the materials and energy which they need for their peculiar functions; at the same time it carries away the waste which the exercise of these functions has produced. It is a characteristic of living body tissue that it can choose the necessary materials from the blood and build them into its own structure. How it does this is one of the mysteries of physiology. The body has also the power of consuming not only the materials of the food, but also parts of its own structure for the production of muscular work, or heat, or to protect more important parts from consumption. How it does this is another mystery.

Excretion.—After the material has been thus assimilated and utilized the resulting waste products must be removed from the body. The chemical elements which this waste contains are the same as those making up the structure of the body and the food—carbon, oxygen, hydrogen, nitrogen, calcium, phosphorus, sulphur, etc. Most of the carbon and part of the oxygen are given off from the lungs as carbon dioxid. Hydrogen unites with more oxygen to form water, which is passed off in vapor from the lungs, in perspiration from the skin, and in urine from the kidneys. Almost all the nitrogen is excreted in the urine. Waste mineral matters are given off to some extent in the perspiration, but mainly through the kidneys and intestines.

APPARENT AND ACTUAL DIGESTIBILITY.

The real nutritive value of a food, then, depends not simply on the proportions of nutrients which it contains, but also on the amount of those nutrients which can be made available to the body by digestion for building material and for fuel. Part of the food eaten escapes digestion and is given off from the body in the feces. If we subtract the amount of this undigested residue from the total food, the remainder will be the amount actually digested in the stomach and intestines absorbed through their walls, and taken into the circulation. This difference between the amounts eaten and those undigested represents the actual digestibility of food. A part of the food taken into the circulation, however, is later returned again to the alimentary canal mainly in the digestive juices that are needed for digesting the food. The material thus removed from circulation and returned to the alimentary canal, which consists of so-called metabolic products, is excreted with the undigested residue in the feces. The remainder of the food taken into the circulation represents the amount retained by the body for building material and for fuel. The difference between the food which is absorbed and that which the body secures, therefore, is represented by the metabolic products. By the present methods of experimenting, however, the portion of the feces that consists of metabolic products can not be satisfactorily distinguished from the undigested residue. It is very difficult, therefore, to determine the actual digestibility, but comparatively easy to estimate the apparent digestibility of food. The terms digestible, indigestible, etc., as here used refer simply to the food which is or is not available for the general nourishment of the body after the process of digestion is completed. In common, however, they are used more loosely as referring to the ease and quickness of digestion, and the general healthfulness of food—bread, for instance—is spoken of as simple and digestible, fruit cake, as rich and indigestible. There is often much practical truth behind such statements, though little is definitely known concerning the time or labor required to digest different kinds of food.

Food does not ordinarily pass from the stomach into the intestine until it has been reduced to a liquid or semi-liquid condition. The amount and consistency of food have a marked influence on the rate of digestion in the stomach. Fluids leave the stomach more rapidly than other materials. Hot drinks do not leave the stomach more quickly than cold ones, nor does the quantity have much effect. Solid matter in solution or suspension delay the passage of fluid from the stomach somewhat. The consistency of solid foods seems to have more effect upon digestibility than the amount consumed. The quantity eaten increases the length of time the material remains in the stomach, but not proportionally.

To select a few examples of the time required for foods to leave the stomach: Two eggs (raw, poached, or in the form of an omelet), 7 ounces sweetbreads, 10 moderate-sized oysters, 7 ounces whitefish or 3½ ounces of white bread, cauliflowers, or cherries, each left the stomach in from 2 to 3 hours. Eight and one-fourth ounces of chicken, 9 ounces of lean beef, 6 ounces boiled ham, 3½ ounces roast veal or beefsteak, 5 1-3 ounces of coarse bread, boiled rice, carrots, spinach, radish, or apple, left the stomach in 3 to 4 hours. Nine ounces of smoked tongue, 3½ ounces smoked beef, 9 ounces roast goose, 5 1-3 ounces string beans, or 7 ounces peas porridge, left the stomach in 4 to 5 hours.

Generally speaking, the most readily digested animal foods were materials of soft consistency. White meats—for example, chicken—leave the stomach more quickly than red meats or dark meat—for instance, duck. The method of cooking also exerts a very marked influence on stomach digestion. Fresh fish was found to be more readily digested than meats.

As regards vegetable foods in general, the consistency and the amounts of solid material were again the principal factors affecting the time required for digestion in the stomach. Mealy potatoes, for instance, were more easily digested than waxy potatoes, and mashed potato more readily than potato cut up in pieces. Fine bread was more quickly digested than coarse bread. There was not much difference in the time required for bread crust, bread crumb, toast, new bread, and stale bread to digest in the stomach, provided all were equally well chewed.—(F. B. 249.)

It must be remembered that digestion continues in the intestine and that the total time required for the digestion and absorption of the nutrients in any given food material is not shown by such experiments. They find their chief application in prescribing a diet for invalids, as in such cases it is often desirable to require of the stomach only a limited amount of work. Physicians have used predigested foods of different sorts for their patients for many years. Since the diastase of malt imitates the work of the diastase of saliva and pancreas so well, it is the common means of predigesting carbohydrates, when that is necessary, just as the preparations of pepsin and pancreatic juice are used for the predigestion of protein. Ordinarily predigested foods are intended for invalids under special conditions, and for them only on the doctor's orders.

About thirty years ago there was a furore over malted fodder for cattle, which it was claimed would greatly increase the strength and flesh of the animals by sparing them part of the work of digestion. It was soon found, however, that the cattle did fully as well when left to perform their own work of digestion in the way that nature intended.

Digestibility is often confused with another very different thing, namely, the agreeing or disagreeing of food with the person who eats it. Different persons are differently constituted with respect to the chemical changes which their food undergoes and the effect produced, so that it may be literally true that one man's meat is another man's poison. Milk is for most people a very wholesome, digestible, and nutritious food, but there are persons who are made ill by drinking it. Dr. Atwater mentions a boy who was made seriously ill by eating eggs. A small piece of sweet cake in which eggs had been used caused him serious trouble. Every person must learn from his or her own experience what food agrees with him or her and what does not.

In making the experiments noted, the subjects are kept on a simple diet, all the food and solid excreta are analyzed, and the difference between the two is taken to represent the amount of food which the body secures for nutriment. From comparing the results of many experiments it has been found that in the total food of an ordinary mixed diet, on the average, about 92 per cent of the protein, 95 per cent of the fats, and 97 per cent of the carbohydrates are retained by the body. A slightly greater per cent of these nutrients are digested in the case of animal food and slightly less in vegetable food.

TABLE II.—*Nutrients and Energy of Digestible Portion of Some Common Foods, With Nutritive Ratios.*

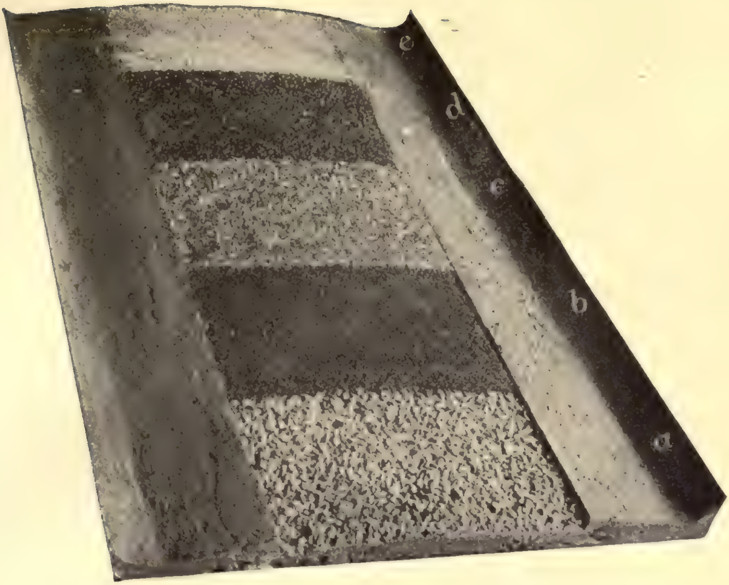
Kind of food materials	Refuse.	Water.	Totals indigestible nutrients.	Digestible nutrients.				Fuel value per pound.	Nutritive ratio.
				Protein.	Fat.	Carbohydrates.	Ash.		
ANIMAL FOOD.									
Beef, fresh:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Calories*	1:
Chuck, ribs	16.3	52.6	1.4	15	14.3	....	0.6	910	2.1
Loin, medium	13.3	52.5	1.6	15.6	16.6	....	.7	1.025	2.4
Ribs	20.8	43.8	1.8	13.5	20	....	.5	1.135	3.3
Round, medium	7.2	60.7	1.4	18.4	12.2	....	.8	890	1.5
Shoulder and clod	16.4	56.8	1.2	15.9	9.3	....	.7	715	1.3
Beef, dried and smoked	4.7	53.7	4.5	25.6	6.6	....	5.5	790	.6
Veal:									
Cutlets, round	3.4	68.3	1.2	19.5	7.1	....	.8	695	.8
Leg	14.2	60.1	1.1	15	7.5	....	.7	625	1.1
Mutton:									
Leg	18.4	51.2	1.4	14.6	14	....	.6	890	2.2
Loin	16	42	2	13.1	26.9	....	.5	1,415	4.6
Pork, fresh									
Loin, chops	19.7	41.8	1.8	13	23	....	.6	1.245	4
Ham	10.7	48	1.9	13.1	24.6	....	.6	1,320	4.2
Pork, salted and smoked:									
Bacon	7.7	17.4	4.4	8.8	59.1	....	3.1	2,720	15.1
Ham	13.6	34.8	3.1	13.8	31.7	....	3.2	1,635	5.2
Salt, fat	......	7.9	5.4	1.8	81.9	....	2.9	3,555	....
Poultry:									
Fowl	25.9	47.1	1.2	13.3	11.7	....	.5	765	2
Turkey	22.7	42.4	1.6	15.6	17.5	....	.6	1,060	2.5
Fish, fresh:									
Cod, dressed	29.9	58.5	.5	10.8	.2	....	.6	220	.1
Mackerel	44.7	40.4	.7	9.9	4	....	.5	370	.9
Shellfish:									
Oysters, solids	......	88.3	.6	5.8	1.2	3.3	.8	225	1
Fish, preserved and canned									
Cod, salt	24.9	40.2	5.1	15.5	.4	....	13.9	325	.1
Salmon, canned	......	63.5	1.9	21.1	11.5	....	2	915	1.2
Eggs, uncooked	11.2	65.5	1.1	12.7	8.8	....	.7	635	1.7
Dairy products:									
Whole milk	......	87	.5	3.2	3.8	5	.5	310	4.3
Skim milk	......	90.5	.3	3.3	.3	5.1	.5	165	1.8
Cream	......	74	1.1	2.4	17.6	4.5	.4	865	18.4
Butter	......	11	4.9	1	80.8	....	2.3	3,410	....
VEGETABLE FOOD									
Cereals, etc.:									
Corn meal	......	12.5	3.3	7.8	1.7	73.9	.8	1.640	10
Oat breakfast food	......	7.8	5.1	14.2	6.6	64.9	1.4	1,800	5.6
Rye flour	......	12.9	2.9	5.8	.8	77.1	.5	1,620	13.6
Rice	......	12.3	2.9	6.8	.3	77.4	.3	1,625	11.5
Wheat flour, patent process	......	12	3.4	9.7	.9	73.6	.4	1,635	7.8
Wheat breakfast food	......	9.6	3.8	10.3	1.6	73.7	1	1,680	7.5
Bread, etc.:									
Bread, white wheat	......	35.3	2.9	7.8	1.2	52	.8	1,200	7
Crackers, cream	......	6.8	4.5	8.2	10.9	68.3	1.3	1,925	11.3
Vegetables:									
Beans, white, dried	......	12.6	7.9	17.5	1.6	57.8	2.6	1,520	3.5
Beets, fresh	20	70	.8	1.1	.1	7.3	.7	160	6.8
Cabbage	15	77.7	.6	1.2	.2	4.6	.7	115	4.2
Potatoes	20	62.6	1.2	1.5	.1	14	.6	295	9.5
Squash	50	44.2	.4	.6	.2	4.3	.3	100	7.8
Sweet potatoes, fresh	20	55.2	1.6	1.2	.5	20.8	.7	440	18.3
Tomatoes	......	94.3	.5	.7	.4	3.7	.4	95	6.6
Fruits:									
Apples	25	63.3	1.2	.3	.3	9.7	.2	190	34.7
Bananas	35	48.9	1.6	.7	.4	12.9	.5	260	19.7
Grapes	25	58	1.7	.9	1.1	13	.3	295	17.2
Oranges	27	63.4	1	.5	.1	7.7	.3	150	15.8
Strawberries	5	85.9	1	.8	.5	6.3	.5	150	9.3

TABLE III.—*Comparative Cost of Digestible Nutrients and Energy in Different Food Materials at Average Prices.*

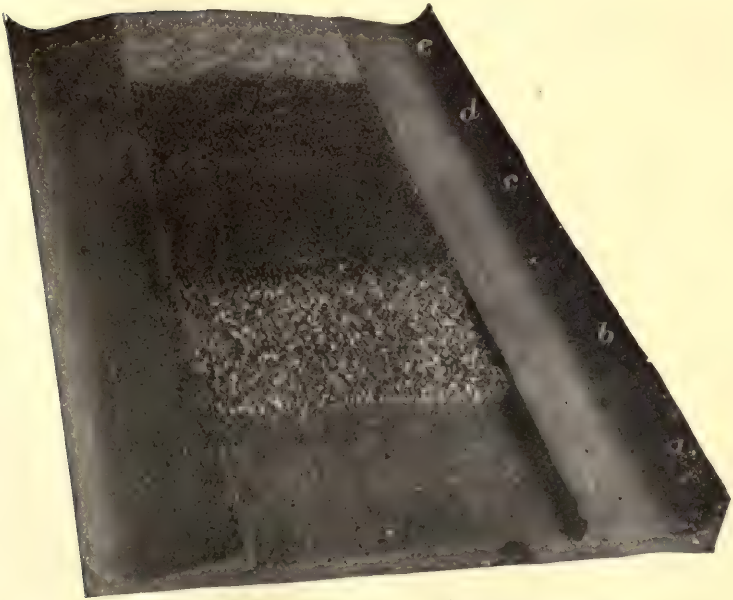
[It is estimated that a man at light to moderate muscular work requires about 0.23 pound of protein and 3.050 calories of energy per day.]

Kind of food material.	Price per pound.	Cost of 1 pound protein. *a*	Cost of 1,000 calories energy. *a.*	Amounts for 10 cents. Total weight of food material.	Amounts for 10 cents. Protein.	Amounts for 10 cents. Fat.	Amounts for 10 cents. Carbohydrates.	Amounts for 10 cents. Energy.
	Cents.	*Dollars*	*Cents.*	*Pounds*	*Pound.*	*Pound.*	*Pounds.*	*Calories.*
Beef, sirloin	25	1.60	25	0.40	0.06	0.06	....	410
Do	20	1.28	20	.50	.08	.08	....	515
Do	15	.96	15	.67	.10	.11	....	685
Beef, round	16	.87	18	.63	.11	.08	....	560
Do	14	.76	16	.71	.13	.09	....	630
Do	12	.65	13	.83	.15	.10	....	740
Beef, shoulder clod	12	.75	17	.83	.13	.08	....	595
Do	9	.57	13	1.11	.18	.10	....	795
Beef, stew meat	5	.35	7	2	.29	.23	....	1,530
Beef, dried, chipped	25	.98	32	.40	.10	.03	....	315
Mutton chops, loin	16	1.22	11	.63	.08	.17	....	890
Mutton, leg	20	1.37	22	.50	.07	.07	....	445
Do	16	1.10	18	.63	.09	.09	....	560
Roast pork, loin	12	.92	10	.83	.11	.19	....	1,035
Pork, smoked ham	22	1.60	13	.45	.06	.14	....	735
Do	18	1.30	11	.56	.08	.18	....	915
Pork, fat salt	12	6.67	3	.83	.02	.68	....	2,950
Codfish, dressed, fresh	10	.93	46	1	.11	....	....	220
Halibut, fresh	18	1.22	38	.56	.08	.02	....	265
Cod, salt	7	.45	22	1.43	.22	.01	....	465
Mackerel, salt, dressed	10	.74	9	1	.13	.20	....	1,135
Salmon, canned	12	.57	13	.83	.18	.10	....	760
Oysters, solids, 50 cents per quart	25	4.30	111	.40	.02	....	.01	90
Oysters, solids, 35 cents per quart	18	3.10	80	.56	.03	.01	.02	125
Lobster, canned	18	1.02	46	.56	.10	.01	....	225
Butter	20	20.00	6	.50	.01	.40	....	1,705
Do	25	25.00	7	.40	....	.32	....	1,365
Do	30	30.00	9	.33	....	.27	....	1,125
Eggs, 36 cents per dozen	24	2.09	39	.42	.05	.04	....	260
Eggs, 24 cents per dozen	16	1.39	26	.63	.07	.06	....	385
Eggs, 12 cents per dozen	8	.70	13	1.25	.14	.11	....	770
Cheese	16	.64	8	.63	.16	.20	.02	1,185
Milk, 7 cents per quart	3½	1.09	11	2.85	.09	.11	.14	885
Milk, 6 cents per quart	3	.94	10	3.33	.11	.13	.17	1.030
Wheat flour	3	.31	2	3.33	.32	.03	2.45	5.440
Do	2½	.26	2	4	.39	.04	2.94	6,540
Corn meal, granular	2½	.32	2	4	.31	.07	2.96	6.540
Wheat breakfast food	7½	.73	4	1.33	.13	.02	.98	2,235
Oat breakfast food	7½	.53	4	1.33	.19	.09	.86	2,395
Oatmeal	4	.29	2	2.50	.34	.16	1.66	4.500
Rice	8	1.18	5	1.25	.08	....	.97	2.025
Wheat bread	6	.77	5	1.67	.13	.02	.87	2,000
Do	5	.64	4	2	.16	.02	1.04	2.400
Do	4	.51	3	2.50	.20	.03	1.30	3,000
Rye bread	5	.65	4	2	.15	.01	1.04	2,340
Beans, white, dried	5	.29	3	2	.35	.03	1.16	3,040
Cabbage	2½	2.08	22	4	.05	.01	.18	460
Celery	5	6.65	77	2	.02	....	.05	130
Corn, canned	10	4.21	23	1	.02	.01	.18	430
Potatoes, 90 cents per bushel	1½	1.00	5	6.67	.1	.01	.93	1.970
Potatoes, 60 cents per bushel	1	.67	3	10	.15	.01	1.40	2.950
Potatoes, 45 cents per bushel	¾	.50	3	13.33	.20	.01	1.87	3.935
Turnips	1	1.33	8	10	.08	.01	.54	1,200
Apples	1½	5.00	8	6.67	.02	.02	.65	1,270
Bananas	7	10.00	27	1.43	.01	.01	.18	370
Oranges	6	12.00	40	1.67	.01	....	.13	250
Strawberries	7	8.75	47	1.43	.01	.01	.09	215
Sugar	6	....	3	1.67	....	....	1.67	2,920

a The cost of 1 pound of protein means the cost of enough of the given material to furnish 1 pound of protein, without regard to the amounts of the other nutrients present. Likewise the cost of energy means the cost of enough material to furnish 1,000 calories, without reference to the kinds and proportions of nutrients in which the energy is supplied. These estimates of the cost of protein and energy are thus incorrect in that neither gives credit for the value of the other.



Model of Tarred Macadam Road. Gladwell Method.
Dept. of Agr.
(See pages 149–165.)



Model of Tar-Slag Macadam Road. Dept. of Agr.

The figures given in Table I do not, then, represent the nutrients actually available for the uses of the body, but those contained in the food before it is eaten. Similarly the fuel value given is not the heat of combustion of the food consumed, but that of the nutrient actually oxidized in the body.

The figures of Table II show the digestible nutrients and available energy in a number of common food materials, as computed from the figures in Table I, by use of the proper factors. The figures in the third column of Table II show the total quantity of indigestible nutrients. The term used as the heading of the last column, nutritive ratio, or, as it is sometimes and perhaps more accurately called, nutrient ratio, requires a word of explanation. The term nutritive ratio is used to express the ratio of digestible protein to digestible fuel ingredients (fats and carbohydrates) in any food material or diet. In calculating this ratio 1 pound of fat is taken as equivalent to 2¼ pounds of carbohydrates—this being approximately the ratio of their fuel values—so that the nutritive ratio is actually that of the protein to the sum of carbohydrates plus 2¼ times the fat. As an example, take the nutritive ratio of corn meal. From Table II we find it has 7.8 per cent of digestible protein, 73.9 per cent of digestible carbohydrates and 1.7 per cent of digestible fat. The nutritive ratio then may be expressed thus:

Protein : Fuel ingredients.
Protein : Carbohydrates plus 2¼ times fat.
7.8 : 73.9 + (2¼ × 1.7)=
7.8 : (73.9 + 3.82+ = 77.72) or 1 : 9.96, which is almost 1 : 10.

The values given in Table II, like those of Table I, represent averages. There are, of course, a number of other foods which may be and are used for human food to some extent. Many of these contain large per cents of nutrients. A few of the uncommon ones are cotton-seed meal and oil, cow peas, soy beans, peanut oil, and even acorn meal used by Indians in California to make a very nutritious bread. The most important of these will be described later.

PECUNIARY ECONOMY OF FOOD.

Although the cost of food is the principal item in the living expenses of a large majority of the people, and although the physical welfare of all is so intimately connected with and dependent upon diet, very few of even the most intelligent have any clear ideas regarding the actual nutriment in the different food materials they use. In too many cases even those who wish and try to economize know very little as to the combinations which are best fitted for their nourishment and have still less information as to the relation between the real nutritive value of different foods and their cost. The question here to be considered is this: Of the different food materials which are palatable, nutritious, and otherwise suited for nourishment, what ones furnish the largest amounts of available nutrients at the lowest cost? In answering this question it is necessary to take into account not only the prices per pound, quart, or bushel of the different materials, but also the kinds and amounts of the actual nutrients they contain and their fitness to meet the demands of the body for nourishment. The cheapest food is that which supplies the most nutriment for the least money. The most economical food is that which is cheapest and at the same time best adapted to the needs of the user.

There are various ways of comparing food materials with respect to the relative cheapness or dearness of their nutritive ingredients.

A good way of estimating the relative pecuniary economy of different food materials is found in a comparison of the quantities of both nutrients and energy which can be obtained for a given sum, say 10 cents, at current prices. This also is illustrated in Table III.

PREPARATION OF FOOD.

Uncooked.—There are many kinds of foods eaten uncooked and we will first consider what preparation, if any, is necessary for these. Among these are fruits, vegetables, nuts, dried and smoked fish, meats and milk.

A German investigator, B. Ehrlich, having estimated by careful experiments the number of bacteria to be found on market fruit, tried different methods of washing it without injuring the flavor. He washed grapes, apples, and pears that had been exposed to street dust, each time examining the wash water for the number of bacteria present. While the first wash water yielded large numbers, the second contained only a few, and the third a negligible number. A basin of water was used for the purpose, the fruit being moved about in it. When running water was used, five minutes' time was allowed. Fruits with a firm, smooth skin should be rubbed before washing with a clean cloth to start the dirt.

The cleaning of delicate berries is a difficult matter. Such fruit should be purchased with care to avoid all that are too soft or which show sand or other visible dirt. Strawberries, because they grow so near the ground, should not be purchased after a rain, which will spatter them with muddy drops. Only the freshest and cleanest berries should be served raw; more doubtful specimens should be cooked. By immersing them in water a few at a time and handling carefully, such fruits may be washed without much loss of flavor.—(F. B. 375.)

Dried figs and dates are very commonly eaten without cooking, or even washing, and yet they have been exposed for an unknown length of time to the contagion brought by dust, flies, and dirty hands. In how many houses are oranges washed before they are brought to the table, or the lemon before it is sliced for the tea or lemonade, or before the skin is grated for flavoring? Yet the skin is often very dirty.

In preparing such fruits as plums, peaches, etc., for the table, the skin may be readily removed, without injury to the flavor by first immersing them for a short time in boiling hot water. A silver knife should always be used for paring apples, pears, and other fruits, as if a steel knife is used the acid of the fruit acts on the iron of the knife and frequently, causes a black discoloration, and there is also very commonly a noticeable metallic flavor. If pared or cut fruit is exposed to the air, it rapidly turns dark in color.

In investigations carried on at the Oregon Agricultural Experiment Station with a view to preventing the discoloration of evaporated fruits and vegetables it was found that treating sliced apples with a weak solution of common salt (1 to 2 per cent) resulted in a product which was very bright and white and of better appearance than that obtained by the well-known domestic method of treatment with cold water. It seems probable that the Oregon method may find application in the household.—(F. B. 293.)

Overripe fruit is often injurious, very probably because it has begun to ferment, and stale or partially decayed fruit is obviously undesirable for food purposes and should be discarded. In addition to a deterioration in flavor there is always the possibility of digestive disturbance if such fruit is eaten. Some prefer fruits served cold and others think they are sweeter and better flavored warmed by the sun. Individual taste must determine at what temperature to serve them.

Salad plants such as lettuce endive, celery, cabbage, should have all tough, coarse parts removed, should be searched leaf by leaf for insects, be washed in several waters, dried with a clean cloth and put in a cold place to become crisp.

Shelled nuts are now common commercial products. They are sometimes sold in tight packages, but more often are not thus protected from dust and insects, and should be washed. Shelled nuts purchased in market should always be washed and scalded before they are used, as they are commonly exposed to dust, and perhaps to flies. They can afterwards be dried on a clean cloth before using. Many careful housewives wash nuts in the shell before cracking, as this prevents accidental soiling of the kernels. In cracking nuts, if one wishes to obtain the meats unbroken, it is necessary, as everyone knows, to hold the nut in such a position that the shell will be crushed along certain definite lines. Thus, hickory nuts must be struck on the thin side and pecan nuts and native butternuts or white walnuts on the end. With such nuts as the almond or filbert less care is needed as the nut is loose in the shell.

There is undisputed evidence to show that shellfish become contaminated when placed in sewage-polluted water. The results of many investigators show that sewage-polluted shellfish have been responsible for the production of typhoid fever and other intestinal diseases. Oysters intended to be eaten on the half shell, above all others, should be produced from beds of unquestionable purity, and they should be consumed preferably while fresh from the beds; although if properly kept at cool temperatures under sanitary surroundings shell oysters may remain wholesome and in good condition for several weeks after dredging.

The liquor in the shell surrounding the oysters contains more bacteria than does an equal volume of meat from the same oyster. This liquor, together with any sand in the gills of the oyster, can be removed and the meat chilled at the same time by the use of pure ice and water. This washing process can be done efficiently within 3 to 10 minutes, depending upon the method employed. Oysters should not be allowed to soak in fresh water, as they increase in volume, change in appearance and flavor, and decompose more rapidly than those not soaked.—(Bur. Chem. B. 136; Dept. Agr. F. B. 293, 375.)

Milk is another food used without cooking. As it is a very nutritious and valuable food and one easily secured on the farm, cooks should become familiar with all the various methods of using it. In milk the principal protein compound is casein. It contains both phosphorus and sulphur. There is also present in milk some albumen—about one-seventh of the entire protein. The fat of milk is found throughout it in small globules. The amount varies from 3 to 5 per cent. The chief carbohydrate is lactose (milk sugar.) It varies from 4 to 6 per cent. It remains in the whey when the curd or casein is removed. The ash in milk consists mainly of chlorids of soda, potash, and lime and makes up about 0.7 per cent of the milk. Milk should be kept in a very clean, cool place free from dirt and flies.

As we have seen from a consideration of the constituents of milk, it is a very valuable food, although by itself not the best for adults. It must be combined with other foods. A lunch of half a pound of bread and a pint of skim milk will furnish .09 pounds of protein and 859 calories, that is, nearly one-third of a day's nutriment. If whole milk is used the fuel value will be 1,080 calories.

On the farm skim milk is often considered fit only for the pigs; but it really may be used in cookery, etc., as a useful and economical food, though it is only fair to say that on a farm milk is often so abundant that the fresh whole milk will naturally be selected for culinary and table purposes. The fresh whole milk seems to most persons more tempting as a beverage, perhaps, than older skim milk, though this is a matter largely of cultivation and habit.

Sour milk or clabber is a common article of diet in many parts of the United States and is wholesome, and to those who care for it very refreshing and palatable. It is certainly nutritious, since when made from whole milk it contains all the nutritive ingredients originally present, and when only skim milk is used it contains the casein and other constituents except the fat. Usually no special methods are followed to prepare sour milk or clabber for table use, though most housewives recognize the fact that if the souring takes place too slowly the clabber may have a bitter or unpleasant flavor. This is, of course, due to the development of undesirable bacteria along with those which cause the souring of the milk.

Cottage cheese as commonly made at home from sour milk with or without the cream is a nutritious and palatable food, 19.6

per cent protein, 23.2 fat, 2.1 carbohydrates, 2.1 ash. Several sorts are made in large quantities as regular commercial products and sold under such names as Neufchatel, or, less commonly, cream cheese. In many city markets the homemade product may also be purchased. Cottage cheese is used as a palatable addition to the diet, alone or seasoned in various ways, and is also used in the preparation of a number of dishes.

Cottage cheese flavored in different ways may be used for sandwiches. Caraway seeds, chopped stuffed olives of different sorts, and chives, (a vegetable which may be easily grown in the kitchen window as well as the kitchen garden) make good flavors. Instead of the different kinds of stuffed olives, plain olives and pimentos may be chopped separately and added, but this requires more work.

The question is likely to arise why sour milk and its products are considered safe food to be eaten raw, while stale sweet milk is looked upon with some suspicion unless it has been cooked. The reason is that for a long time after the milk is drawn all the bacteria which enter into it increase in number, the increase being more or less rapid, depending chiefly on the temperature at which the milk is kept. Some of these bacteria may be kinds that produce disease. Finally, however, when milk sours the harmless lactic-acid bacteria and the lactic acid which they produce tend to destroy other microorganisms, including the disease-producing bacteria, so that the time comes when the harmful bacteria decrease very rapidly and the lactic-acid bacteria increase very rapidly. By the time the milk is sour it is practically free from bacteria, except those of the lactic-acid type.

Buttermilk is often used as a beverage, and has much the same food value as skim milk. An ordinary glass would contain about as much nourishment as 2 ounces of bread, a good-sized potato, or a half pint of oysters. To many persons buttermilk is as palatable, or even more palatable, than whole or skim milk, but others find the sour taste very unpleasant. This sour taste is due mainly to lactic acid, and does not make the buttermilk less digestible. On the contrary, its casein forms a more flaky curd than that of ordinary milk. Buttermilk is frequently fed to babies, especially in Holland, and is sometimes prescribed when the protein of ordinary milk proves indigestible. Its general use is increasing in this country. Buttermilk ice cream is considered a delicacy in some sections, especially for invalids.

Condensed buttermilk is manufactured to some extent, but seems to be best known in Europe, and is certainly not common even there. When cream is beaten or *whipped* the fine bubbles formed do not break readily, so that it may be whipped until it is stiff, almost like egg white. If the whipping is too long continued the fat globules separate, and butter results. If cream is too thin it does not whip well, and the same may be said of very thick cream. Several explanations of this property of whipping have been offered, but it seems fair to say that no entirely satisfactory explanation has been given. That the property may be dependent upon the calcium content of the milk is suggested by the fact that cream to which a small amount of a solution of lime in sugar and water has been added may be readily whipped. This question has been carefully studied at the Wisconsin station, and it was found that if a small portion of such a lime solution was added to pasteurized cream which ordinarily does not whip readily, or to thin cream, satisfactory results could be obtained.—(F. B. 363.)

MODIFIED, CERTIFIED, AND HOMOGENIZED MILK FOR INFANTS.

It is universally admitted that the best food for infants is milk from strong, healthy women. When this is not obtainable the more nearly the substitute resembles it the better. Cow's milk is the most common substitute, and when necessary this is artifically modified to make it resemble human milk more closely. While cows milk contains about the same proportion of total solids and fat as woman's milk it carries more protein and less milk sugar. The deficiency in milk sugar in the cow's milk can easily be made good by adding either milk sugar itself or some other digestible carbohydrate, such as rice flour or arrowroot. The casein may be made more easy of digestion by the addition of limewater, or may be artifically predigested by peptonizing. But nothing can exactly reproduce the protein of human milk.

Fortunately, most healthy babies thrive on good cow's milk or cow's milk simply modified. It is the sickly who require special preparations, and their needs vary so greatly that only the physician acquainted with the case, and not always he, can say what change is necessary.

SPECIAL INFANT FOODS.

There are numerous patent infant and invalid foods on the market, some of which contain cow's milk as a basis combined with varying amounts of carbohydrates or other constituents, and others which seem to be made of farinaceous materials without milk. Too much credence should not be given to the extravagant claims made for some brands of infant foods. The safest course is undoubtedly to follow the advice of a competent physician. It is often wiser to use modified cow's milk in preference to these commercial foods, and it can be easily prepared at home under a physician's directions.

All babies fed on raw cow's milk are in more or less danger from the undesirable bacteria which it may contain and which cause diarrhea and other serious infant disorders. When raw milk is used, great pains should be taken not only to obtain fresh, clean milk, but also in caring for it scrupulously. It is usually more important that the milk should be pure than that it should be rich in cream.—(F. B. 363, 413.)

PREPARATION OF FOOD—COOKING.

The cooking of food has much to do with its nutritive value. Many articles which, owing to their mechanical condition or other cause, are quite unfit for nourishment when raw are very nutritious when cooked. Well-cooked food is wholesome and appetizing, while the same material badly cooked is unpalatable. There are three chief purposes of cooking. The first is to change the mechanical condition so that the digestive juices can act upon the food more freely. Heating often changes the structure of food materials very materially, so that they are more easily chewed and more easily and thoroughly digested. The second is to make it more appetizing by improving the appearance or flavor, or odors. Food which is attractive to the taste quickens the flow of saliva and other digestive juices, and thus digestion is aided. The third is to kill by heat any disease germs, parasites, or other dangerous organisms it may contain. This is often a very important matter, and applies to both animal and vegetable foods.—(Dept. Agr. F. B. 142.)

MEATS.

Studies of the food habits of people living in the temperate and warmer regions of the world, where animal and vegetable foods are both found in abundance and where there is opportunity for choice, show that, while vegetable foods—cereals, succulent vegetables, and fruits—compose the greater part of the bulk of the diet, animal foods—dairy products, eggs, meat, and fish—almost invariably enter into the bill of fare. For many reasons it seems fair to conclude, with the majority of the physiologists, that this widespread habit is the result of experience and that it has its foundation in bodily needs. From the earliest times, in fact, man has used animal foods, and his whole body structure is adapted to the use of such articles of diet.

The value of meat as food depends chiefly on the presence of two classes of nutrients, (1) protein or nitrogenous compounds, and (2) fat. The mineral matter it contains, particularly the phosphorus compounds, is also of much importance, though it is small in quantity. Protein is essential for the construction and maintenance of the body and both protein and fat yield energy for muscular power and for keeping up the temperature of the body. Fat is especially important as a source of energy. It is possible to combine the fat and protein of animal foods so as to meet the requirements of the body with such materials only, and this is done in the Arctic regions, where vegetable food is lacking; but in general it is considered that diet is better and more wholesome when, in addition to animal foods, such as meat, which is rich in proteins and fats, it contains vegetable foods, which are richest in sugar.

According to statistics compiled in the office of experiment stations, meat furnishes about 16 per cent of the total food consumed in the ordinary American family, about 30 per cent of the protein desirable in the average diet, and 60 per cent of the energy-producing fats. It is possible to obtain all of the necessary protein and energy from other materials but it is doubtful if it would be either desirable or agreeable for the average person. Exactly how much meat should be eaten is a difficult matter to determine; probably if one meat dish is served a day, and other materials supplying protein, such as milk, eggs, beans, or similar foods, are also used, there is little danger of getting too much meat or too little protein.

Average Composition of Edible Portion of Different Cuts of Meat.

Kind of meat.	Water.	Protein.	Fat.	Ash.	Fuel value per pound.
Beef:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Calories.*
Brisket	54.6	15.8	28.5	0.9	1,495
Chuck rib	66.8	19.0	13.4	1.0	920
Flank	59.3	19.6	21.1	.9	1,255
Porterhouse	60.0	21.9	20.4	1.0	1,270
Neck	66.3	20.7	12.7	1.0	920
Ribs	57.0	17.8	24.6	.9	1,370
Round	67.8	20.9	10.6	1.1	835
Shank	70.3	21.4	8.1	.9	740
Side	62.2	18.8	18.8	.9	1,145
Veal: Side, with kidney, fat, and tallow	71.3	20.2	8.1	1.0	715
Mutton: Side, without tallow	53.6	16.2	29.8	.8	1,560
Lamb: Side, without tallow	58.2	17.6	23.1	1.1	1,300
Pork:					
Tenderloin	66.5	18.9	13.0	1.0	900
Chops	50.7	16.4	32.0	.9	1,655

The difference between the cuts is chiefly in the amount of the fat and consequently in the fuel value. So far as the proteins are concerned, very little difference is found in the items included in the table. The cooking of meats develops the pleasing taste and odor of extractives and that due to the browned fat and tissues and softens and loosens the protein (gelatinoids) of the connective tissues, and thus makes the meat more tender. Extreme heat, however, tends to coagulate and harden the albuminoids of the lean portions, and also weakens the flavor of extractives. If the heating is carried too far a burned or charred product of bad flavor results.—(F. B. 142.)

Meats lose weight in cooking. A small part of this is due to escape of meat juices and fat, but the chief part of the material lost is simply water. The nutritive value of a meat soup depends upon the substances which are dissolved out of the meat, bones, and gristle by the water. In ordinary meat broth these consist almost wholly of extractives and salts, which are very agreeable and often most useful as stimulants, but have little or no value as actual nutriment, since they neither build tissue nor yield energy. The principles which underlie the cooking of fish are essentially the same as with meats.

The thoroughness with which a given food material may be digested can be studied satisfactorily only by means of natural digestion experiments in which the quantities of nutrients in the material eaten are determined and compared with those in the feces excreted. Such experiments are sometimes made with dogs and other animals, but the most satisfactory are those made with men. Only those made with men are here considered.—(O. E. S. 193.)

Numerous studies of the effect of different methods of cooking upon the thoroughness and ease of digestion of meat have been made. Many valuable studies have been made at the University of Illinois by H. S. Grindley and others.

In one bulletin the results of 67 digestion experiments with men are given. These experiments were of two kinds. In 23 of them the meat was eaten in a rather varied ration, the purpose being to determine the effect of different methods of cooking meat upon the digestibility of an ordinary mixed diet, including meat, beef being the meat selected. In the remaining 44 experiments the meat was eaten in a very simple diet, the food materials other than meat being those the digestibility of which is fairly well established, so that by making due allowance for these the digestibility of the meat itself may be calculated. Of these, 31 experiments were with beef cooked in water for one, two, and three hours, and by roasting, frying, and pan broiling; and 6 were with veal, 3 with mutton, and 4 with pork, all roasted. The results of the experiments with beef show the effects of different methods of cooking upon the digestibility of the meat, and a comparison of the results with the various meats cooked in the same way shows the relative digestibility of different kinds of meat.

In all the experiments with simple diet a study was made of the amounts of metabolic nitrogen in the feces, and in all the 67 experiments the urine was collected and the balance of income and outgo of nitrogen was determined.

In the twenty-three natural digestion experiments with men the same kind of meat—beef round—cooked in various ways, was eaten with several other common food materials in a rather varied diet. The average digestibility of the nutrients of the total diet was as follows: Protein, 93 per cent; fat, 98 per cent; carbohydrates, 97 per cent. These coefficients agree very closely with those found in the average of several hundred digestion experiments with varied diet.

Differences in method of cooking the meat had no appreciable effect upon the proportions of nutrients digested and absorbed from the total diet. In forty-four experiments different kinds of meat—beef, veal, mutton, and pork—cooked in various ways, were eaten with two or three other common food materials in a very simple diet, and the digestibility of the meat alone was determined. In the average of the results of these experiments the digestibility of the protein was 98 per cent and of the fat 98 per cent.

Differences in the results obtained with different kinds of meat or with the same kind of meat cooked in different ways were too small to be of any practical significance. The relative fatness of the meat had no appreciable effect upon the thoroughness of digestion, the nutrients of very fat meat being digested as completely as those of very lean meat, including that from which in some cases part of the visible fat had been removed before cooking. In short, all the kinds and cuts of meat were very thoroughly digested, whatever the method of cooking, and when allowance was made for the metabolic products in the feces, the results obtained indicated that the nutrients of the meat were completely digestible.

It is commonly said that meats of different sorts vary decidedly in digestibility; for instance, that red meat is less digestible than white meat or beef than pork, or that a cheap cut is less digestible than a tender steak. As regards the thoroughness of digestion the results of the extended series of tests reported show that such differences do not exist in any appreciable degree, and that meat of all kinds and cuts is to be classed with the very digestible foods.

Meat is undeniably one of the more expensive items in the food bill of the ordinary family, and it is important that it be bought and used to the best possible advantage. In rural communities cooperative slaughterhouses and storage houses are often useful not only in reducing the cost of meat, but in making fresh meat available in summer. If the size of her family or her storage facilities warrant, the housekeeper may find it advantageous to buy the whole carcass of a small animal, such as a pig or a lamb, or a large section of beef, thus securing better prices.

It is also important to reduce waste by using as much as possible of the bone, fat, and trimmings, not usually served with the meat itself. The bones and trimmings can almost always be profitably used in the soup kettle and the fat can be saved for cooking, thus saving the more expensive butter and lard. The bits of meat not served with the main dish or remaining after the first serving can be seasoned and recooked in many palatable ways, as in croquettes, salads, or can be combined with vegetables, rice, hominy, dumplings, toast, biscuits, macaroni, pie crust, etc., and thus the meat flavor may be extended over a large quantity of less expensive food with such combinations.

Different kinds and cuts of meat vary considerably in price. Sometimes the cheaper cuts contain a larger proportion of refuse than the more expensive, and the apparent cost is less than the actual cost of the edible portion. Aside from this the advantage of the more expensive cuts lies in tenderness and flavor rather than in nutritive value. Tenderness depends on the character of the muscle fibers and connective tissues of which the meat is composed. Flavor depends partly on the fat present in the tissues, but mainly on nitrogenous bodies known as extractives, which are usually more abundant or of more agreeable flavor in the more tender parts of the animal. The heat of cooking dissolves the connective tissues of tough meat and in a measure makes it more tender, but heat above the boiling point or even a little lower tends to change the texture of muscle fibers. Hence tough meats must be carefully cooked in low heat, long applied in order to soften the connective tissue without unduly changing the fibers. For this slow cooking a casserole, Aladdin oven, fireless cooker, or the simmering burner of the gas stove may be used. Cooking, especially in water, presents a further danger, namely, the escape into the water of the nutritious material in the meat. In cases where the liquid in which the meat is cooked is to be used, as in soups and some stews, this is of less importance or it may even be an advantage, but where the meat only is to be used the fact must always be taken into consideration. Not only is the amount of nutritive material in the meat lessened, but the extractives are lost and with them more or less of the flavor the meat originally possessed. To lessen the chances of loss, cooks frequently sear the exterior of the meat either in hot fat or in boiling water before beginning the long cooking, or tough meat may be pounded or chopped to break down the tissues to a certain extent, and thus permit shorter cooking. Besides using such devices as browning meat in fat to retain and develop the natural flavor of the meat, other flavors may be added to supplement them. These may be put into the meat before cooking or may be added later in the form of relish or sauce.

Vegetables of distinctive flavor such as onions, carrots, or celery; savory herbs such as parsley, sage, bay leaf, or thyme; and materials such as vinegar, pickles, or currant jelly; spices such as pepper, cloves, or curry mixtures; and sharp or highly seasoned meat sauces are all types of flavoring materials which are useful for such purposes and which may be used in a great variety of ways.

In fact, the number of tasty dishes which a good cook can make out of the cheaper cuts of meat or meat left over is almost endless. Undoubtedly more time and skill are required in their preparation than in the simple cooking of the more expensive cuts, just as more time and skill are required for careful, intelligent marketing than for haphazard ordering; but the real superiority of a good cook lies not so much in the preparation of expensive or fancy dishes as in the attractive preparation of inexpensive dishes for every day and in the skillful combination of flavors.

The advantages of variety in the methods of preparing and serving are to be considered even more seriously in the cooking of the cheaper cuts than in the cooking of the more expensive ones, and yet even in this connection it is a mistake to lose sight of the fact that, though there is a great variety of dishes, the processes involved are few in number.—(O. E. S. 141.)

An experienced teacher of cooking says that she tries to reduce the cooking of meat to its lowest terms and teach only three ways of cooking. The first is the application of intense heat to keep in the juices. This is suitable only for portions of clear meat where the fibers are tender. By the second method the meats are put in cold water and cooked at a low temperature. This is suitable for bone, gristle, and the toughest portions of the meat, which for this purpose should be divided into small bits. The third is a combination of these two processes and consists of searing and then stewing the meat. A few recipes, somewhat uncommon, are here given:

Fat.—A double boiler is the best utensil to use in trying out small portions of fat as there is no danger of burning and less odor. Excepting where the purpose of clarifying fat is to remove flavors, a good method is to pour boiling water over the fat, to boil thoroughly, and to cool. The cold fat may be removed in a solid cake and any impurities clinging to it may be scraped off.

A slight burned taste or similar objectionable flavors often can be removed from fat by means of potatoes. After melting the fat, put into it thick slices of raw potato; heat gradually. When the fat ceases to bubble and the potatoes are brown, strain through a cloth placed in a wire strainer.

For Savory Drippings.—To these add a small onion (do not cut it), a few leaves of summer savory and thyme, a teaspoonful of salt, and a little pepper.

Stewed Shin of Beef.—Four pounds of shin of beef, 1 medium-sized onion, 1 whole clove and a small bay leaf, 1 sprig of parsley, 1½ tablespoonfuls of flour, 1 small slice of carrot, ½ tablespoonful of salt, ½ teaspoonful of pepper, 2 quarts of boiling water, 1½ tablespoonfuls of butter or savory drippings.

Have the butcher cut the bone in several pieces. Put all the ingredients but the flour and butter into a stewpan and bring to a boil. Set the pan where the liquid will just simmer for six hours, or after boiling for five or ten minutes, put all into the fireless cooker for eight or nine hours. With the butter, flour, and one-half cupful of the clear soup from which the fat has been removed, make a brown sauce; to this add the meat and the marrow removed from the bone. Heat and serve. The remainder of the liquid in which the meat has been cooked may be used for soup.

Boiled Beef with Horseradish Sauce.—Plain boiled beef may also be served with horseradish sauce, and makes a palatable dish, or with a little chopped parsley sprinkled over it. The meat may be browned like pot roast before serving.

Stuffed Heart.—Wash the heart thoroughly inside and out, stuff with the following mixture, and sew up the opening: One cup broken bread dipped in fat and browned in the oven, 1 chopped onion, and salt and pepper to taste. Cover the heart with water and simmer until tender or boil ten minutes and set in the fireless cooker for six or eight hours. Remove from the water about one-half hour before serving. Dredge with flour, pepper, and salt, or sprinkle with crumbs and bake until brown.

Turkish Pilaf.—One-half cup of rice, ¾ cup of tomatoes stewed and strained, 1 cup stock or broth, 3 tablespoonfuls of butter.

Cook the rice and tomatoes with the stock in a double boiler until the rice is tender, removing the cover after the rice is cooked if there is too much liquid. Add the butter and stir it in with a fork to prevent the rice from being broken. A little catsup or chili sauce with water enough to make three-quarters of a cup may be substituted for the tomatoes. This may be served as a border with meat, or served separately in the place of a vegetable, or may make the main dish at a meal, as it is savory and reasonably nutritious.

Mock Rabbit.—One-half pound round steak and 1 pound sausage; or 1 pound round steak and ½ pound sausage meat; 3 slices of bread moistened with water, 1 egg, 1 onion, ¼ pound salt pork, pepper and salt.

Chop the meat. Chop the onion and cook (but do not brown) it in the fat tried out of a small portion of the pork. Add the bread and cook a few minutes. When this is cool, mix all the ingredients and form into a long round roll. The surface can easily be made smooth if the hand is wet with cold water. Lay the remaining pork cut in thin slices on top and bake forty minutes in a hot oven. The sausage may be omitted if desired and other seasoning used. There is sometimes an advantage in using canned meat and meat products, and, if they are of good quality, such products are wholesome and palatable.

Hungarian Goulash.—Two pounds top round of beef, a little flour, 2 ounces salt pork, 2 cups tomatoes, 1 stalk celery, 1 onion, 2 bay leaves, 6 whole cloves, 6 peppercorns, 1 blade mace. Cut the beef into 2-inch pieces and sprinkle with flour; fry the salt pork until light brown; add the beef and cook slowly for about thirty-five minutes, stirring occasionally. Cover with water and simmer about two hours; season with salt and pepper or paprika. From the vegetables and spices a sauce is made as follows: Cook in sufficient water to cover for twenty minutes; then rub through a sieve, and add to some of the stock in which the meat was cooked. Thicken with flour, using 2 tablespoonfuls (moistened with cold water) to each cup of liquid, and season with salt and paprika. Serve the meat on a platter with the sauce poured over it. Potatoes, carrots, and green peppers cooked until tender, and cut into small pieces or narrow strips, are usually sprinkled over the dish when served, and noodles may be arranged in a border upon the platter.

Chickens.—In many parts of the country, especially on farms, chicken is probably much cheaper than beef, as only the cost of production needs to be considered. When chickens, and, for that matter, any poultry, can be raised with little labor and can find most of their food or use up otherwise useless table refuse, skim milk, etc., they ought to be a very economical and agreeable substitute for pork and beef, and to be used liberally.

The methods of cooking poultry are in general the same as those for other kinds of meat. The tougher the bird the more cooking will be needed to make it tender and easily digested, and the larger it is the more heat will be required to cook it thoroughly. Canned and potted poultry are prepared in much the same way as freshly cooked dishes, and when properly put up do not differ essentially from similar fresh foods.

As regards composition, poultry does not differ as much as is commonly supposed from meat of other domestic animals used for food. Individual kinds and specimens, of course, vary in the relative amounts of protein and fat contained, and there are certain flavors present in poultry which differ from those in other meats. But these differences are so small that they are practically negligible in ordinary diet. Nor is there as much difference in digestibility as is often stated. On the average, poultry is somewhat more easily digested than beef and mutton, but only very slightly.

Fish.—Fish contain the same kinds of nutrients as other food materials. The place of fish in the diet, if judged by its composition, is therefore the same as that of meat—that is, it supplements cereals and other vegetables, the most of which, as wheat, rye, maize, rice, potatoes, etc., are deficient in protein, the chief nutrient in the flesh of fish. As regards the relative nutritive value of meat and fish, Atwater's conclusion, from a large number of investigations, was that the only considerable difference is in the proportion of water and fat present, the flesh of the fish having water where meat has fat.

From the standpoint of both nutritive value and palatability fish is an important food product and, as shown by experiments, equal to beef as a source of energy in the diet. It produces the same sensation of satiety and this persists for as long a time. It was found that fish caused the excretion of a smaller amount of uric acid than meat.

Fish in one form or another is almost universally recognized as an important food material, and enters to some extent into the diet of very many if not the majority of American families.—(Dept. Agr. F. B. 85, 142, 182, 391; O. E. S. 102, 141, 162, 193; F. B. 391.)

Cheese.—In considering the use of cheese in quantity as an integral part of the diet there are many possibilities from simple combinations like bread and cheese to elaborate dishes in which cheese is used as a flavor and as a principal constituent. As has been pointed out, cheese, being rich in both protein and fat, would logically replace such foods as meat, fish, and eggs. An ounce of cheese roughly is equivalent to 1 egg, to a glass of milk, or 2 ounces of meat.

The Office of Experiment Stations reported the case of a man who lived for months upon a diet of bread, fruit, and cheese, and who remained in good health and active, and did not weary of the monotony of the diet. The bread and the cheese could have been taken in such amounts as to constitute a balanced ration, but taken with the fruit, made a ration which was well balanced. The watery and refreshing fruits or succulent vegetables with their large supply of cellulose are a pleasant contrast to the concentrated and fatty cheese.

Housekeepers would probably find that if in planning menus of which a cheese dish is the chief feature they were to take pains to supply also crisp, watery vegetables, water cress, celery, lettuce served with a dressing or with salt alone, or simple fruit salads, and would give preference to refreshing fruits, either fresh or cooked, rather than to what are known as heavy desserts, they would in general be more successful in pleasing those who are served.—(Dept. Agr. F. B. 487.)

Rice Fondue.—One cupful of boiled rice, 2 tablespoonfuls of milk, 4 eggs, 1 cupful of grated cheese, ½ teaspoonful of salt, 1 teaspoonful of some commercial meat sauce, or similar flavoring.

Heat the rice in the milk, add the other ingredients, and cook slowly until the cheese is melted. Serve on crackers or toast. The food value is not far from that of a pound of beef of average composition, and the calculated cost is 15 cents.

Corn and Cheese Souffle.—One tablespoonful of butter, 1 tablespoonful of chopped green pepper, ¼ cupful of flour, 2 cupfuls of milk, 1 cupful of chopped corn, 1 cupful of grated cheese, 3 eggs, ½ teaspoonful of salt.

Melt the butter and cook the pepper thoroughly in it. Make a sauce out of the flour, milk, and cheese; add the corn, cheese, yolks, and seasoning; cut and fold in the whites beaten stiffly; turn into a buttered baking dish and bake in a moderate oven 30 minutes. Made with skimmed milk and without butter, this dish has a food value slightly in excess of a pound of beef and a pound of potatoes.

Nut and Cheese Roast.—One cupful of grated cheese, 1 cupful of chopped English walnuts, 1 cupful of bread crumbs, 2 tablespoonfuls of chopped onion, 1 tablespoonful of butter, juice of half a lemon, salt and pepper.

Cook the onion in the butter and a little water until it is tender. Mix the other ingredients and moisten with water, using the water in which the onion has been cooked. Pour into a shallow baking dish and brown in the oven.

Cheese and Spinach Roll.—Two quarts of spinach, 1 cupful of grated cheese, 1 tablespoonful of butter, salt, bread crumbs.

Cook the spinach in water for 10 minutes. Drain off the water, add the butter, cook until tender, and chop. Add the cheese and the eggs and bread crumbs enough to make a mixture sufficiently stiff to form into a roll, or leave more moist and cook in a baking dish.

Vegetable and Cheese Rolls.—For the spinach of the above recipe there may be substituted beet tops, Swiss chard, or the outer leaves of lettuce.

STRUCTURE AND COMPOSITION OF VEGETABLES.

Plants are made up of innumerable cells, each consisting of a thin membranous wall inclosing a semifluid mass, in which lies the nucleus or center of cell activity and minute grains of starch or other material which the plant has elaborated (manufactured).

The whole framework of the very young plants is made up of these cell walls, commonly called cellular tissue or cellulose. However, early in the growth of the plant wood cells begin to develop. The wood cells grow into a fibrous substance that may be torn apart like threads, which is called woody fiber. It is this woody fiber and the thickening and hardening of the cellular tissue that make poorly grown or stale vegetables hard and indigestible.

Practically all green plants contain a large percentage of water with a larger or smaller percentage of starch and some nitrogenous material (protein), sugar, gum, crude fiber, and other carbohydrate and mineral matter. The fruits and seeds of some plants are rich in fat, but the plant itself rarely contains any appreciable amount of this constituent. If green plants are covered so that light can not reach them, changes take place in the cells, and the chlorophyll (green coloring matter) is bleached out. It is commonly believed that strong flavors diminish, and this is one reason for covering salad plants from the light in order that they may become blanched. The growth made without light is more tender than the normal growth. This is another reason why such salad plants as endive and celery are blanched before they are used. In the household the term blanching has other meanings. Thus, nuts, like almonds, are blanched when the brown outer skin is removed by treatment with hot water, and vegetables are blanched in cooking, as described a few paragraphs below. Most vegetables contain small amounts of volatile essential oils or other bodies of pronounced flavor and owe their characteristic taste to such constituents; sugars and acids when present, as they often are, and mineral salts, found in all vegetable foods, also contribute their share toward the flavor.

CLASSIFICATION OF VEGETABLES.

Vegetable foods may be divided into a few general classes. These are cereals, legumes, tubers, roots and bulbs, herbaceous or green vegetables, and vegetable fruits and flowers. Rice and corn will be the only vegetables here considered, as they are the only grains commonly employed as table vegetables.

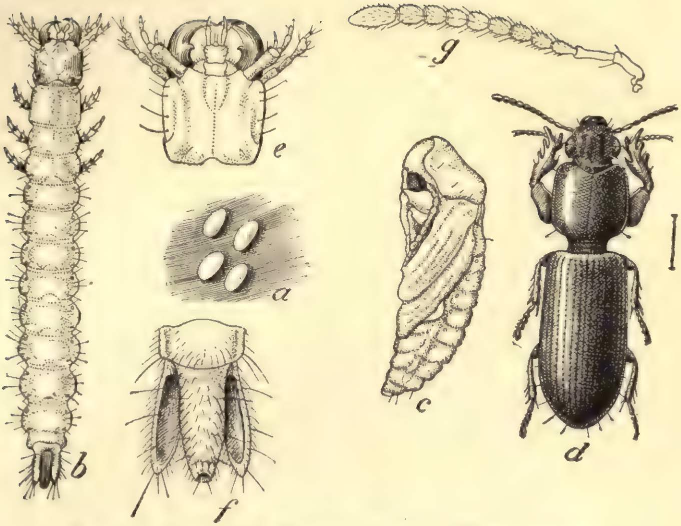
Rice is largely composed of starch and has very small proportions of nitrogenous, fatty, and mineral matter. When used as a vegetable, it is naturally and very properly served with foods rich in the constituents which it lacks. The starch granules in rice are small and angular, and it is generally conceded to be easily digested. Corn, when ripe, also has a high percentage of starch in addition to a fair proportion of the other nutrients. Green corn is a succulent vegetable containing a fair proportion of carbohydrates in addition to a small proportion of the other nutrients.—(Bu. Chem. 127.)

In the freshly pulled corn the sugars present are 4.59 and 4.74 per cent. On standing twenty-four hours at room temperature, unhusked, about one-third of the sugars disappear; after the next twenty-four hours another loss is noticed, but when the sugars reach 1.80 per cent no further decrease takes place. The taste is not so good after twenty-four hours as when first pulled. After ninety-six hours the corn tasted flat and sour and the kernels were wrinkled. Legumes belong to the pulse family. The fruit is usually in the shape of a pod. Only a few kinds are used as table vegetables, beans, peas, cowpeas, and lentils being the most common.

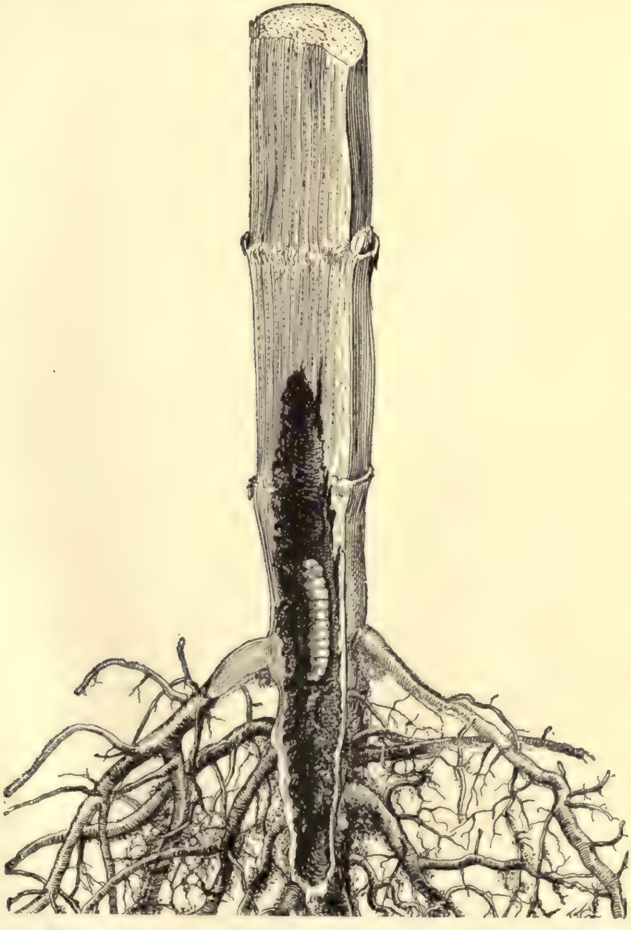
The ripe leguminous seeds are very rich in nitrogenous matter. Peas, beans, cowpeas, and lentils contain on an average 25 per cent nitrogenous matter and over 50 per cent starch, and about 10 per cent cellulose, fatty matter, and mineral matter. When properly cooked and consumed in reasonable quantities peas, beans, and lentils may replace a portion of the meat in the daily dietary. The unripe legumes and their edible pods, like all green vegetables, are quite succulent foods, the proportion of nutritive material being small as compared with the water present. The green seeds and the green pods of peas and beans are not so highly nutritious as the dried seed, but they are more delicate and apparently more easily digested.

Among the foods served as table vegetables, tubers and roots have an important place. The potato comes next to the cereals in its almost universal employment and the material consumed. We have no other vegetable that lends itself to such a variety of preparations. It contains a large percentage of water, a fair percentage of starch, a very small percentage of sugar, and nitrogenous, fatty, and gummy matter, and about 1 per cent of mineral matter. The mineral matter consists of potash and soda salts, citrates, phosphates, magnesia, and silicate of lime. It is to this mineral matter that the potato owes its antiscorbutic properties (that is, it prevents scurvy).

The sweet potato is rich in starch and sugar. The percentage of nitrogenous and fatty matter is very small. This vegetable makes a



SLENDER SEED-CORN GROUND-BEETLE. DEPT. OF AGR.



WORK OF LARGER CORNSTALK BORER. DEPT. OF AGR.

pleasant and healthful addition to the table. It is somewhat laxative.

The Jerusalem artichoke, a fairly common tuber used as a vegetable, is a species of sunflower. The name is a corruption of girasole, the Italian name for sunflower. The Jerusalem artichoke tubers can be left in the ground during the winter; they are welcome and refreshing in the spring when fresh vegetables are scarce.

The true roots most used as table vegetables are beets, radish, turnips, parsnips, carrots, salsify, and celeriac. Both the parsnip and salsify withstand frost and may be left in the ground all winter, thus making it possible to have these vegetables in the early spring as well as in the fall.

The bulb-bearing plants belong to the lily family, the onion being the bulb most generally used as a vegetable and flavorer. On the Continent of Europe very many other members of the onion family are also freely used as flavorers, and no continental kitchen garden would be considered complete without several varieties, such as the common onion, leek, shallot, garlic, chives, and cibol. Much of the delicious flavor of the French and Italian cookery is due to the skillful combination of several of the onion flavors.

The herbaceous vegetables, cabbage, lettuce, celery, spinach, etc., are valuable for their refreshing qualities, the salts they yield, and the variety they give to our diet, but owing to the amount of water they contain (90 per cent or more on an average) their food value is low. The leaves, stems, and shoots are the parts used as food. These vegetables should be employed while young and tender. The list of herbaceous vegetables is long and includes the cabbage tribe, celery, asparagus, and all the green leaves, stalks, and shoots that are employed, cooked, or used as salads.

Fruits used as vegetables include tomatoes, okra, squash, pumpkin, cucumber, eggplant, and peppers, among others. Such fruits as muskmelon and watermelon are used as fruits rather than as vegetables, and are not taken up here. In the case of globe or French artichoke, cauliflower, and broccoli the flower buds or inflorescence are the parts eaten.

GENERAL PRINCIPLES UNDERLYING VEGETABLE COOKING.

Vegetables are baked, roasted, fried, or boiled, are used for making a great variety of dishes, and are prepared for the table in other ways; but the most common method of cooking them is in boiling water. Steaming is not infrequently resorted to as a method of cooking vegetables and is, of course, similar in principle to boiling in water.

The simpler the methods of cooking and serving vegetables the better. A properly grown and well-cooked vegetable will be palatable and readily digestible. Badly cooked, water-soaked vegetables very generally cause digestive disturbances, often serious. Nearly every vegetable may be cooked so that with plain bread it may form a palatable course by itself, if it is desired to serve it in this manner.

All green vegetables, roots, and tubers should be crisp and firm when put on to cook. If for any reason a vegetable has lost its firmness and crispness, it should be soaked in very cold water until it becomes plump and crisp. With new vegetables this will be only a matter of minutes, while old roots and tubers often require many hours. All vegetables should be thoroughly cleaned just before being put on to cook. Vegetables that form in heads, such as cabbage, cauliflower, and Brussels sprouts, should be soaked, heads turned down, in salted cold water, to which a few spoonfuls of vinegar may be added. If there are any worms or other forms of animal life in these vegetables, they will crawl out. To secure the best results all vegetables except the dried legumes must be put in boiling water, and the water must be made to boil again as soon as possible after the vegetables have been added, and must be kept boiling until the cooking is finished. Herbaceous vegetables should boil rapidly all the time. With tubers, roots, cauliflower, etc., the ebullition should not be so violent as to break the vegetables. Green beans and peas when removed from the pod must also be cooked gently, i. e., just simmer. When the pods and all are used they are to be cooked rapidly, like the herbaceous vegetables.

To secure the most appetizing and palatable dishes, only fresh tender vegetables should be cooked. If, however, green beans, peas, etc., have grown until a little too old and it still seems best to gather them, a very small piece of baking soda added to the water in which they are boiled makes them more tender, it is commonly believed, and helps to retain the color. Too much soda injures the flavor, and an excess must be carefully avoided. A little soda may also be used to advantage if the water is quite hard. Peas may be boiled for fifteen or twenty minutes in the water to which the soda has been added, then to be cooked as usual.

During the cooking of all vegetables the cover must be drawn to one side of the stewpan to allow the volatile bodies liberated by the heat to pass off in the steam. All vegetables should be thoroughly cooked, but the cooking should stop while the vegetable is still firm except when they are cooked in soups, purees (thick strained soups), etc. The best seasoning for most vegetables is salt and good butter. Vegetables that are blanched and then cooked with butter and other seasonings and very little moisture are more savory and nutritious than when all the cooking is done in a good deal of clear water.

Blanching in cookery is a cooking process often used with vegetables, since it removes the strong or acrid taste and improves the quality. It is also convenient, since blanching may be done at any time, and the cooking completed in a very short time when the dish is to be served. Drop them into the boiling water, and boil rapidly, with the cover partially or wholly off the stewpan, five to twenty minutes, depending upon the vegetable, then drain off the water. If the cooking of the vegetable is not to be finished at once, pour cold water over the vegetable to cool it quickly, then drain and set aside until needed. If the cooking is to be continued at once, it will not be necessary to rinse the vegetable with cold water. To complete the cooking the vegetable should be put in a small stewpan with butter or drippings and the other seasonings and cooked gently until done. A few spoonfuls of liquid will be required for every quart of very juicy vegetables, and half a pint of liquid for drier vegetables. The stewpan is to be covered, only a slight opening being left for ventilation. All vegetables cooked in this manner should be cut up rather small either before or after the blanching.

In preparing vegetables for the table remove all inedible portions and see that the total amount of refuse is as small as is consistent with good quality. Thin paring of potatoes and other vegetables is an economy which it is worth while to practice, and is an easy way of decreasing useless loss.

LOSSES IN COOKING VEGETABLES.

In baking vegetables there is little loss of material except the water which is driven off by the heat. When vegetables are immersed in water, as in boiling, a greater or less loss of material is almost inevitable, the kind and amount of material extracted by the water depending upon such factors as the sort of water used, its temperature at the beginning and during the cooking period, the length of time the cooking is continued, and the condition of the vegetable, that is, whether pared, whole, or cut into small pieces.

In experiments carried on under the auspices of the Office of Experiment Stations it was found that when potatoes were boiled in the jackets the loss of material was very trifling. When peeled and soaked for several hours before boiling, the loss amounted to about 50 per cent of the nitrogenous material, and 40 per cent of the mineral matter present. When peeled and placed at once in boiling water, only about 8 per cent of the proteid matter and 19 per cent of the mineral matter present were extracted by the water. Little starch was dissolved, but when peeled potatoes were boiled the amount of starch removed by abrasion was at times nearly 30 per cent of the total value of the potato.

In the experiments with carrots it was found that the loss was greatest when the roots were cut into small pieces, amounting in this case to nearly 30 per cent of the total food material present. The sugar extracted when the carrots were boiled was equivalent to nearly a pound to the bushel. When cabbage was boiled the amount of material extracted was found to be about one-third of the total food material present, the chief constituents extracted by the water being ash or mineral matter. Some recent German experiments have shown that when vegetables are steamed only one-third as much material is removed as when they are boiled.

CHANGES THAT TAKE PLACE IN COOKING VEGETABLES.

The cellular tissue is softened and loosened; the nitrogenous substances are coagulated; the starch granules absorb moisture, swell, and burst; and flavors and odors are developed. As long as the vegetable is kept at a temperature above 125° F. changes continue to go on in the vegetable substance. The most marked of these are in the starch and in the odor, color, and flavor of the vegetable. Starch will not dissolve in cold water, but pure starch gelatinizes readily in hot water, and if the temperature is high enough will become gummy and opaque. If starch is cooked in just moisture enough to swell and burst its granules and is then kept hot, but without additional moisture, a change will continue to take place, though the starch will remain dry and glistening. The flavor grows sweeter and more nutty the longer the starchy food cooks in dry heat. It is only vegetables that are composed largely of starch that can be kept hot in this manner without acquiring a strong taste and poor color. Potatoes, if kept in a closely covered vessel or with the unbroken skins on, will become soggy and dark and have a rank flavor. This is owing to the retention of moisture, which changes some of the starch to a sticky gummy mass, and very probably to the noxious volatile bodies which are generated by heat and should be allowed to pass away. If the skins are broken and the vessel ventilated, potatoes may be kept warm a long time without spoiling.

During the cooking of all kinds of foods gases are developed which, if retained in the food, give it a strong flavor and odor, and which, there is reason to believe, are injurious. What all these gases are and just how they act is not yet known, because very little research has been made along these lines.

Carbonic-acid gas is liberated from practically all foods and sulphureted hydrogen or other volatile sulphur compound from practically all except the starchy vegetables. If the food be thoroughly ventilated while cooking, the gases will pass off in the steam. Foods which are well ventilated during cooking are better flavored than those which are closely covered and are more wholesome. Hence the urgent necessity for thorough ventilation while cooking vegetables or any other foods.

Overcooking changes and toughens the texture of vegetable foods and destroys the chlorophyll and other coloring matters and volatilizes or injures the bodies which contribute to the flavor. Overcooked vegetables are inferior in appearance and flavor and often indigestible (that is, promotive of digestive disturbance) as well as unpalatable.

Cowpeas.—These are a common leguminous vegetable in the southern United States and are also called black-eye peas, whip-poor-will peas, lady peas, cornfield peas, etc. They are most excellent cooked like shelled beans when green. The young pods are also served like string beans. The ripe, dry beans, which are also very palatable and nutritious, may be cooked like dried beans or lentils.

Scarlet Runner Beans.—In Great Britain the scarlet runner beans, which are raised in the United States almost exclusively as an ornamental plant, are highly prized for the table. The tender green pods are whittled into small sections (after stringing) and cooked in water until just tender. These beans are at their best seasoned only with butter and salt.

Swiss Chards.—This vegetable is a variety of beet in which the leaf stalk and midrib have been developed instead of the root. It is cultivated like spinach, and the green, tender leaves are prepared exactly like this vegetable. The midribs of the full-grown leaves may be cooked like celery.

Stewed Cucumbers.—Stew pared cucumbers, cut in quarters or in thick slices, for fifteen minutes in a saucepan with a little water and a minced shallot or a small minced onion. Pour off the water; stir in a little flour, butter, and salt; heat for two or three minutes, and then serve.

Cucumber Saute.—Boil pared and quartered cucumbers for three minutes only. Then drain the pieces and season with salt and pepper. Roll in flour and cook in a saucepan with butter for twenty minutes. This dish may be varied by adding minced parsley, chives, and chervil about five minutes before the cooking is finished.

Tomatoes.—The tomato, although not very nutritious, may be classed as one of our most useful vegetables. Raw, it makes an attractive and refreshing salad and may be served by itself or in combination with other vegetables, with meat or with fish. As a vegetable the tomato may be prepared in many ways. It makes a good foundation for soups and sauces. Made into catsup or pickles it serves as a relish. The addition of a little tomato gives a pleasant, acid flavor to many soups and sauces, and also to meat, fish, and vegetable dishes. If possible the tomatoes should ripen fully on the vines, as the flavor is much better than when picked green and then allowed to ripen. Overcooking spoils the flavor and color of the tomato.

Rice.—Wash 1 cupful of rice in several waters, rubbing the grains between the hands to remove all the dirt. Put the washed rice in a stewpan with 2½ cupfuls of water and 1 teaspoonful of salt. Cover and place where the water will boil. Cook for twenty minutes, being careful not to let it burn. At the end of this time put the stewpan on a tripod or ring and cover the rice with a fold of cheese cloth. Let it continue to cook in this manner an hour, then turn into a hot vegetable dish. The rice will be tender, dry, and sweet, and each grain will be separate. During the whole process of cooking the rice must not be stirred. If a tablespoonful of butter is cut up and sprinkled over the rice when it has cooked twenty minutes the dish will be very much improved.

Peas With Pork.—One quart peas, 4 ounces pork; 1 tablespoonful butter, 1 gill water (½ cupful), 2 small white onions, ⅛ teaspoonful pepper.

Cut pork into small bits. Put butter into stewpan and on the fire. When the butter is melted add the pork and cook gently until a light brown, then add the water, peas, onions, and pepper. This is a good way to cook peas when they are a little old and hard.

Spinach has little food value, but its refreshing and slightly laxative qualities make it a valuable adjunct to the more substantial foods. It contains little starch and only a suggestion of sugar, and is therefore one of the vegetables that physicians include in the bill of fare of many invalids who require a diet without these carbohydrates.

Seasonings and Sauces for Vegetables.—Much of the excellence of well-cooked vegetables depends upon the proper use of seasonings and sauces. The seasoning selected should undoubtedly be suitable for the dish, but so much depends upon custom that only general suggestions can be made. The Italians and some other races are much fonder of garlic than Americans, the Germans of summer savory or bohnenkraut in string beans, and the English of mint with peas. Each housewife must select the seasonings which her family prefers and endeavor to use them in such a way that the special flavors may be most satisfactorily brought out.

Salads and Salad Dressings.—Nearly all vegetables may be served in the form of salad. The salads made with the raw vegetables are more refreshing and perhaps more generally relished than those made with cooked vegetables. The most common green salad plant in the United States is undoubtedly lettuce, and perhaps celery, alone or mixed with other materials, next. Endive, chicory, blanched dandelion, and other plants should also be used, as they give a pleasant variety to the menu. Such salads are garnished like lettuce.

CEREALS.

There is such a bewildering variety of cereal breakfast foods, on the market, with such differences in appearance, taste, and claims to nutritive value, that it is hard to choose between them. Of the five cereals corn, oats, rice, wheat, and barley, most commonly used for breakfast foods, oats contain perhaps the largest quantities of the important nutrients, with a fairly low proportion of crude fiber. Wheat ranks very close to oats and even when prepared with the bran is freer from crude fiber. Although the bran contains much protein, digestion experiments indicate, that the crude fiber makes the whole material so much less digestible that more protein is actually available to the body when the bran is excluded. The bran-containing preparations should be avoided by persons of weak digestion, but are often useful in cases of constipation. Appearance, palatability, and relative cost will always and rightly be important features in the selection of these cereal breakfast foods. Corn and its preparations are rich in carbohydrates and fat, but are slightly less digestible than the other cereals. Rice is poor in protein, but remarkably free from crude fiber, and furnishes a large proportion of digestible carbohydrates. Barley contains a fair proportion of nutrients and is moderately digestible. All these differences in composition and digestibility are comparatively slight and may be disregarded by healthy persons living on the ordinary mixed diet.

Thorough cooking not only makes the cereals more palatable, but also breaks down the walls of indigestible cellulose which surround the starch grains and other nutrients and produces other changes so that the digestive juices can work on the nutritive ingredients more effectively. Poorly cooked cereals are less palatable than well cooked and may cause indigestion and be really harmful. When the partially cooked preparations are used, care should be taken to insure sufficient recooking before serving. The ready-to-eat brands are apparently thoroughly cooked.

Unless something is added during the process of manufacture, all brands must have just about the same composition as the cereals from which they are made, as manipulation can not increase the amount of food material in a cereal product, though it may modify its appearance and flavor. It is safe to assume that the predigested goods do not contain a much larger proportion of soluble—i. e., partially digested—starch than any thoroughly cooked cereal. The matter is of little importance to healthy persons, since they are probably better off for doing their own normal work of digestion.

Breakfast cereals of all sorts are usually free from harmful adulterants and in the case of package goods reach the consumer clean and fresh. Prices run from 3 cents to 15 cents a pound but the proportion of nutrients pound for pound does not differ greatly. Partially cooked and ready to eat brands cost more but are more easily prepared. The extent to which they may be used for convenience, flavor and variety must be determined individually.

In selecting cereal breakfast food the consumer may be guided by the analyses of disinterested chemists, by the digestibility as determined by actual tests, by cost, taste, economy, or observed effects on individuals. All things considered they are as a class nutritious, convenient, reasonably economical, and worthy of a place in the diet when judiciously combined with other foods. Below are given a few tables to show the actual value of some of the cereal preparations and a few of the statements made on the packages.

TABLE *A.—Chemical Composition of Breakfast Foods; (Natural Condition).*

No.	Name	Water.	Fat.	Protein.	Fiber.	Carbohydrates.	Ash.
1	Korn Krisp	4.39	3.23	10.79	2.24	76.44	2.91
4	Granose Flakes	5.84	1.65	13.64	3.65	72.73	2.49
6	Malta Vita	4.78	1.60	13.20	4.24	73.17	3.00
13	Force	5.57	.87	12.20	2.88	75.72	2.76
15	Grape Sugar Flakes	5.65	1.03	10.83	2.83	77.36	2.30
28	Vim	7.23	1.75	14.91	2.73	70.07	2.51
29	Egg-O-See	6.56	1.29	12.32	1.70	74.51	2.62
32	Malted Cream Crisp	9.41	1.26	12.41	2.88	71.55	2.49
3	Norka	4.70	5.14	15.70	2.43	69.47	2.56
10	Grape Nuts	3.06	.85	12.63	2.52	79.23	1.71
12	Malta Ceres	5.66	.47	13.68	2.10	76.67	1.42
14	Malt Nut	6.46	3.77	14.90	2.19	69.59	3.00
16	Granola	5.63	.96	14.56	1.87	75.75	1.23
30	Triscuit	6.30	1.77	12.23	2.61	75.52	1.57
5	Shredded Whole wheat	6.26	1.43	16.27	3.33	70.98	1.73
33	Malt Breakfast Food	8.95	1.44	16.14	3.16	69.03	1.28
34	Apitezo	2.52	.28	21.10	1.57	71.99	2.54
	Unprepared Breakfast Foods.						
2	California Wheatine	6.91	2.25	13.16	2.25	74.07	1.36
9	Pillsbury's Vitos	6.46	1.08	12.98	.70	78.33	.45
11	Cream of Wheat	8.83	.60	13.07	.79	76.23	.48
18	Ralston's Health Food	9.58	.77	14.34	1.63	72.83	.85
31	White's Wheat Flakes	11.31	1.86	15.57	2.71	66.78	1.77
	Mother's Crushed Oats	6.55	7.23	16.14	3.69	64.64	1.75
8	Quaker Rolled Oats	6.44	6.32	16.45	2.93	65.67	2.19
17	Ralston Health Oats	6.76	6.81	16.44	3.26	64.95	1.78
19	Ralston Hominy Grits	4.62	.00	9.51	1.87	80.41	.59
20	Ralston Barley Food	6.80	.48	10.51	1.78	79.57	.86
	Miscellaneous Foods.						
21	Continental Soda Biscuit	5.73	9.71	10.65	2.22	70.57	1.12
22	Uneeda Biscuit	5.99	9.95	10.44	1.26	71.12	1.24
23	American Hulled Beans	6.62	2.11	26.80	2.44	58.51	3.52
25	Improved Process H. U. Split Peas	6.98	.68	24.83	1.75	62.48	3.28
26	Potato Chips	4.63	38.59	5.65	2.19	44.77	4.17

TABLE B.—*Total and Digestible Nutrients and Fuel Value of Cereal Breakfast Foods and Some Other Foods.*

Kind of food.	Proportion of total water and nutrients in food.						Proportion of digestible nutrients in food.				Fuel value per pound.
				Carbohydrates.							
	Water.	Protein.	Fat.	Nitrogen-free extract.	Fiber.	Ash.	Protein.	Fat.	Carbohydrates.	Ash.	
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Cals.*
Oat preparations:											
Oats, whole grain	11.0	11.8	5.0	59.7	9.5	3.0	......	......	......	......	......
Oatmeal, raw	7.3	16.1	7.2	66.6	.9	1.9	12.5	6.5	65.5	1.4	1,767
Rolled oats, steam-cooked	8.2	16.1	7.4	65.2	1.3	1.8	12.5	6.7	64.5	1.4	1,759
Flaked and malted oats	7.9	16.2	5.2	66.7	1.6	2.4	12.6	4.7	66.3	1.8	1,709
Flaked oats, to be eaten raw	8.6	13.1	7.8	68.8		1.7	10.2	7.0	66.7	1.3	1.742
Wheat:											
Whole grain	10.5	11.9	2.1	71.9	1.8	1.8	......	......	......	......	......
Cracked wheat	10.1	11.1	1.7	73.8	1.7	1.6	8.1	1.5	68.7	1.2	1,501
Rolled wheat, steam-cooked	10.6	10.2	1.8	74.1	1.8	1.5	8.5	1.6	70.7	1.1	1.541
Flaked and crisped, ready to eat	9.4	12.2	1.4	72.7	1.9	2.4	8.9	1.3	67.9	1.8	1,500
Flaked, crisped, and malted, ready to eat	9.0	12.1	1.4	73.0	1.8	2.7	9.1	1.3	68.4	2.0	1,526
Shredded wheat	8.1	10.6	1.4	76.0	2.1	1.8	7.7	1.3	71.1	1.4	1,521
Coarsely ground, parched at factory	8.0	14.2	3.1	72.3	1.0	1.4	11.5	2.8	70.1	1.1	1,699
Crumbed and malted	5.6	12.2	1.0	77.6	1.7	1.9	9.1	.9	73.7	1.4	1,623
Coarsely ground, decorticated	9.6	12.5	1.0	76.0	.5	.4	10.1	.9	73.1	.3	1,632
Flaked, to be eaten raw	10.0	9.9	2.1	76.2		1.8	7.2	1.9	69.3	1.4	1,500
Farina	10.9	11.0	1.4	75.9	.4	.4	8.9	1.3	72.9	.3	1,609
Patent roller process flour	12.0	11.4	1.0	74.8	.3	.5	......	......	......	......	1,650
Entire wheat flour	11.4	13.8	1.9	71.0	.9	1.0	......	......	......	......	1,675
Graham flour	11.3	13.3	2.2	69.5	1.9	1.8	......	......	......	......	1,670
Rye:											
Whole grain	11.6	10.6	1.7	72.5	1.7	1.9	......	......	......	......	......
Flaked, to be eaten raw	11.1	10.0	1.4	75.8		1.7	7.8	1.3	71.1	1.3	1,526
Barley:											
Whole grain	10.9	12.4	1.8	69.8	2.7	2.4	......	......	......	......	......
Pearled barley	11.5	8.5	1.1	77.5	.3	1.1	6.6	1.0	73.0	.8	1,514
Flaked, steam-cooked	8.8	10.6	.8	77.7	1.2	.9	8.2	.7	74.0	.7	1,569
Flaked, to be eaten raw	10.8	8.9	1.1	77.9		1.3	6.9	1.0	73.1	1.0	1,525
Buckwheat:											
Flour	13.6	6.4	1.2	77.5	.4	.9	5.0	1.1	73.1	.7	1,471
Farina	11.3	3.3	.3	84.6	.1	.4	2.6	.3	79.4	.3	1,480
Groats	10.6	4.8	.6	83.1	.3	.6	3.7	.5	78.2	.5	1,503
Corn:											
Whole grain	10.9	10.5	5.4	69.6	2.1	1.5	......	......	......	......	......
Corn meal, unbolted	11.6	8.4	4.7	74.0		1.3	6.2	4.2	73.2	1.0	1,728
Corn meal, bolted	12.5	9.2	1.9	74.4	1.0	1.0	6.8	1.7	74.6	.8	1,662
Hominy	10.9	8.6	.6	79.2	.4	.3	6.4	.5	78.7	.2	1,671
Flaked, parched	7.3	10.1	1.8	77.2	1.2	2.4	7.5	1.6	77.5	1.8	1,734
Pop corn, popped	4.3	10.7	5.0	77.3	1.4	1.3	7.9	4.5	77.8	1.0	1,882
Hulled corn	74.1	2.3	.9	22.2		.5	1.7	.8	21.8	.4	492
Rice:											
Whole rice, polished	12.3	6.9	.3	80.0		.5	5.8	.3	78.4	.4	1,546
Flaked, steam-cooked	10.2	8.3	.3	79.7	1.2	.3	6.9	.3	79.2	.2	1,595
Puffed rice	7.1	6.2	.6	85.7		.4	5.1	.5	84.0	.3	1,639
Popped rice	.7	8.6	.2	90.0		.5	7.1	.2	88.7	.4	1.754
Wild rice:											
Whole grain	9.9	13.7	.9	72.7	1.2	1.6	......	......	......	......	......
Parched	9.6	13.0	.9	74.0	1.1	1.4	10.1	.8	70.4	1.1	1,565
Kafir corn:											
Flour	16.7	6.6	3.8	69.5	1.2	2.2	5.1	3.4	66.3	1.7	1,452
Meal	16.1	11.2	.5	68.1	2.0	2.1	8.7	.5	65.8	1.6	1,426
Bread, entire wheat	38.4	9.7	.9	48.5	1.2	1.3	8.0	.8	46.7	1.0	1,079
Bread, Graham	35.7	8.9	1.8	51.0	1.1	1.5	6.8	1.6	47.4	1.1	1,081
Bread, white	35.3	9.2	1.3	52.6	.5	1.1	8.1	1.2	52.0	.8	1,203
Crackers	6.8	10.7	8.8	71.4	.5	1.8	9.1	7.9	70.5	1.4	1,905
Macaroni	10.3	13.4	.9	74.1		1.3	11.6	.8	72.2	1.0	1,660
Beans, dried	12.6	22.5	1.8	55.2	4.4	3.5	17.6	1.6	57.8	2.6	1,434
Peas, dried	9.5	24.6	1.0	57.5	4.5	2.9	19.2	.9	60.1	2.2	1,487
Potatoes, raw	78.3	2.2	.1	18.0	.4	1.0	1.6	.1	18.2	.8	369
Beefsteak	66.0	20.3	13.6	......	......	1.1	19.9	12.9	......	.8	950

In Table B the different cereal breakfast foods are arranged in groups, but trade names are not used. If the housewife who is interested in any special brand will take note of its physical characteristics and appearance, she should be able to determine the class in which it should be included, and so decide as to its comparative value.

In the cereals the starch and other nutrients are held in cells of woody fiber. Heat and water combined soften the fiber and rupture the cell walls so that the digestive juices can readily penetrate to the nutrients. The time of cooking required varies with the amount and character of fiber, the size of the pieces, and the degree of cooking which cereals may have had in the course of manufacture. Thus, coarse hominy requires longer cooking than fine hominy or corn meal; wheat grits than rolled wheat, oatmeal than rice. Corn preparations require longer cooking than any of the others, there being more fiber in corn. Wheat and oats are much alike in respect to the amount of cooking they require. Insufficiently cooked cereals are considered to be less easily digested than well cooked, partly because the starch grains are surrounded with a mucilaginous proteid material. This condition disappears with long cooking. Boiling temperature affects the protein, making it somewhat more difficult of digestion. A long cooking at a lower temperature is better.

TABLE C.—*Proportion of Ingredients and Time of Cooking Cereal Breakfast Foods.*

Description of Cereal.	Cereal.	Water.	Salt.	Time of boiling.		Additional time of cooking in double boiler.
	Cups.	*Cups.*	*Teaspoons.*	*Hrs.*	*Mins.*	*Hours.*
Oatmeal, crushed, raw	1	4	1	....	10	8
Oatmeal, rolled, steamed	1	3	1	....	10	1½
Corn meal	1	4	1	....	10	3
Fine hominy	1	5	1	....	10	4
Coarse hominy (soak twelve hours)	1	10	2	4	....	1
Wheat grits, raw	1	5	1	....	10	4
Wheat, rolled, steamed	1	3	1	....	10	1½
Coarse, granular wheat preparations	1	6	1	....	10	¾
Farina	1	4	1	....	....	½
Rice (to be boiled)	1	12	2	....	20	....
Rice (to be steamed)	1	3	1	....	5	¾ to 1

Instead of a double boiler a hay box or fireless cooker may be used to cook the cereals. Directions for making one will be found under Household Conveniences.—(Iowa Exp. St. Bul. 74; Wyoming Exp. St. Bul. 33; Michigan Exp. St. Bul. 211; O. E. S. Bul. 200, 202; F. Bul. 249, 298; Ontario Dept. Agr. Bul. 162.)

BREAD.

The simplest kind of bread making consists in mixing the meal or flour with water and baking it, thus producing what is known as unleavened bread, the common cracker, or English biscuit. Bread of this nature is dry and hard and, unless baked in a very thin cake, is difficult to masticate. The bread most preferred, however, is that which has been raised, or leavened, by producing in the dough a gas that will render it porous. Such bread is light and moist and easy to masticate.

Meal or flour from any of the cereals may be used for unleavened bread, but leavened bread can be made only from those which contain gluten, a mixture of vegetable proteids which when moistened with water becomes viscid, and is tenacious enough to confine the gas produced in the dough. Most cereals, like barley, rice, oats, and corn are deficient or wholly lacking in gluten, and hence can not be used alone for making leavened bread. Rye and wheat, which contain an abundance of gluten, are best fitted for bread, wheat being in this country more commonly used.

Macaroni, vermicelli, and other forms of Italian paste constitute a very important class of foods made from wheat. In food value and in use in the dietary they are very similar to unleavened bread. For the finest of these materials a very hard sort of wheat has lately assumed importance in this country, and is known best as macaroni wheat.

The grain of rye, similar to that of wheat, differs in some features. The rye loaf is not as light and well raised as that of wheat. Rye flour when used alone produces the dark-colored bread which is extensively used in European countries, in many of which it forms the staple article of diet among the poor people, rye flour there being cheaper than wheat. It is commonly regarded as inferior to wheat bread in flavor, but approaches it closely in nutritive value. Rye flour mixed with a considerable proportion of wheat flour makes a much better bread than rye flour alone.

YEAST.

Keeping the above facts in mind, it is easy to understand the leavening effect of yeast in dough. The yeast, working in the warm water and flour, feeds on sugar originally present or else produced from the starch grows and spreads throughout the dough, giving off carbon-dioxid gas, which forces its way between the tenacious particles of gluten and lightens the dough.

Scientifically speaking, yeast is a minute fungus. A single plant is a round or oval one-celled microscopic body which reproduces in two ways—either by sending out buds which break off as new plants or by forming spores which will grow into new plants under favorable conditions. It grows only in the presence of moisture, heat, and nutritive material. Yeast develops best at a temperature of 77° to 95° F. (25° to 35° C.) It is believed that some nitrogen is necessary for the best development of yeast, and that such development is most complete in the presence of free oxygen.

RAISED BREAD, GENERAL METHODS.

Ordinarily a baker mixes his dough with water. Sometimes, especially in private families, milk is used in the place of part or all of the water. Such dough is slower in rising but makes an equally light loaf. Milk bread contains more proteids and fats than water bread, and is equally digestible. Its use is by all means to be advocated, especially on farms where skim milk is abundant. The hardness or softness of the water used makes little difference in the quality of the bread. Salt is used in bread because it imparts a flavor without which bread is usually considered insipid, and because it retards fermentation.

When the flour is of good quality, the dough well prepared, and the bread properly baked, the loaf has certain definite characteristics. Thus it should be well raised and have a thin, flinty crust, which is neither too dark in color nor too tough, but which cracks when broken. The crumb, as the interior of the loaf is called, should be porous, elastic, and of uniform texture, without large holes, and should have a good flavor and odor. In this connection the bread-making and judging contests in some of the household science departments of the farmers' institutes are of interest. The members are urged to bring loaves of their own baking to the meetings, and these are judged on such points as flavor, lightness, grain and texture of the dough, color, depth and texture of the crust, and marked on special score cards with as much accuracy as is used in seed or stock judging contests among farmers. If housekeepers would judge the bread baked in their own kitchens with the same intelligent interest and profit by their findings they could soon learn to make bread as accurately as wholesale bakers.

Substitutes for Yeast.—Partly because yeast is uncertain in its workings, partly too, because it uses up some of the nutritive ingredients of the bread by feeding upon them, attempts have been made to find some substitute for it. Various chemicals have been used to produce carbon-dioxid gas in the dough. The first noteworthy attempts were made about the middle of the nineteenth century at Harvard University and in Germany. Yeast powder, as the American preparation was called, was a mixture of an acid and an alkaline powder, the former calcium phosphate and the latter bicarbonate of soda. When duly mixed with the dough, these were supposed to give off carbon dioxid as effectively as yeast. Liebig, who calculated that in Germany the daily loss of material by the growth of the yeast plant was, if saved, sufficient to supply 400,000 persons with bread, made a great effort to introduce a similar preparation into Germany, but with little success. Numerous baking powders, made from various chemicals, are in the market now. The self-raising flour used in the United States is a flour ready mixed with such a preparation. In the United States leavening agents other than yeast are more commonly used for such kinds of bread as tea biscuit and batter cakes, or for cake and pastry, than for loaf bread. Soda, cream of tartar, or saleratus biscuit are examples of breads frequently made in the home with these chemical leavening agents.

The aerated bread, so popular in London, is made by a different method, invented by the English physician Dauglish in 1856. According to this method, the water used for wetting the dough is directly charged with the requisite amount of carbon-dioxid gas and then mixed with the flour in a specially constructed machine. Sometimes a little fermented barley infusion from a brewery, or wort, is put into the water. Other breads are made by using leaven, Scotch barm, or the wild yeasts as in the salt-rising bread.

Preparation of Dough.—As yeast grows best in temperature of 77° to 95° all materials should be at least luke warm, but not hot. Heat kills the yeast. The dough must be well kneaded to mix the yeast throughout the mass and also that each part should come in contact with the oxygen of the air. Too little yeast gives a poorly raised loaf, too much a coarse, badly flavored one. Three pounds of flour to one pint of water is the average rule for proportions of flour and liquid, but this depends on the flour used and only practice can teach the exact quantities to use. Many use household bread machines to do the kneading and find them very satisfactory, saving time and labor and producing a fine grained, excellent bread.

The ways of mixing dough most used in this country are probably those known as straight dough and sponge dough.

Straight Dough.—This or offhand dough, as it is sometimes called, is made by mixing all the materials at one time, and then setting the mass in a warm place to rise for ten hours or more before baking. It requires more yeast and stronger flour than other methods in which the yeast is allowed to grow in an especially favorable medium before being mixed with the main dough, and needs a longer time to rise, but on the other hand gives an unusually large yield in bread. It is convenient in family bread making, especially when strong compressed yeast is used, as the dough can be mixed overnight and baked in the morning.

Sponge Dough.—This method is best adapted to fancy working, and makes equally good crusty loaves or light biscuit. To make the "sponge," as the bread mixture is commonly called, the yeast is allowed to work for eight or ten hours in a portion of the flour or water. This is then mixed with the remaining materials and left to rise a few hours before baking. The sponge is "slacker"—that is, contains more water than offhand dough, and thus gives the yeast a better chance to work. Sponge-made bread usually rises evenly and well, and can be worked into almost any shape. It has the further advantage of keeping well. Like offhand dough, it can be started the night before it is baked.

Baking and Cooling.—In the earliest days of bread making the dough was simply put into the ashes of the fire or on hot stones to bake. The bread goes into the oven a rather solid, uniform mass and comes out a light, porous body of increased volume with a crisp, dark exterior—the crust—and a firm, spongy interior—the crumb. Let us first see what happens in the crumb. This heats more slowly than the outside; indeed, the moisture which it contains prevents its temperature from rising much above the boiling point of water (212° F.). When first put into the oven the yeast continues working, but a temperature of 158° F. kills it. The gas in the dough, however, still expands, and, forcing its way outward, enlarges the loaf and gives it a spongy appearance. The gluten becomes stiffened by the heat, so that even after the gas in the bubble-like pores has escaped the walls still retain their shape. The starch granules and perhaps the protein compounds undergo chemical changes which render them more digestible. Meanwhile, the crust is becoming hard and dark; the heat changes its starch into stiff gum and sugar and dries out the moisture; the brown color is due to chemical changes known as caramelization.

The heat in the oven should not be too great at first, or the outside of the bread will harden too quickly and the interior will not be done before the crust is thick and dark; further, the gas expanding in the crumb will be unable to escape through the crust and will lift up the latter, leaving great holes beneath it. To prevent too rapid formation of the crust, bakers sometimes moisten the tops of their loaves before putting them into the oven or have devices for passing steam over them during the baking. The steam also changes some of the starch into a sort of gum on the top of the loaf and gives it the shiny look so often seen in Vienna bread. The same effect can be produced by moistening the top of the loaf just before it is taken from the oven. Cooks sometimes get a similar result by spreading the top of the bread lightly with butter. For ordinary purposes a baker heats the oven to 400° or 500° F. and lets a pound loaf bake an hour or an hour and a quarter; small rolls perhaps half an hour. On being taken from the oven, bread should be placed on slats or sieves so that the air can circulate about it until it is thoroughly cooled. By that time all the gas and steam which are likely to escape have done so, and the bread may be put away. Some housekeepers wrap their hot bread in cloths, but this is not advisable, not only because it makes the bread taste of the cloth, but also because it shuts the steam up in the loaf and makes it damp and clammy—an excellent medium for cultivating mold.

Baking Tests.—It has already been indicated that gluten is the ingredient of the flour on which its bread-making properties chiefly depend. All gluten is composed of two bodies called gliadin and glutenin, and the principal factor which determines the character of the gluten is the proportion of gliadin to glutenin in it. The gliadin, a sort of plant gelatin, is the material which binds the flour particles together to form the dough, thus giving it tenacity and adhesiveness; and the glutenin is the material to which the gliadin adheres. If there is an excess of gliadin the dough is soft and sticky, while if there is a deficiency it lacks in expansive powers. Many flours containing a large amount of gluten and total proteid material, and possessing a high nutritive value, do not yield bread of the best quality.

Some Minnesota experiments were planned to test the question whether it is the starch content or the gluten content that determines the bread-making quality of the flour. In certain cases the proportion of starch in a normal flour was increased 10 to 20 per cent by the addition of wheat starch, while in others it was decreased to the same extent, and in still others 10 to 20 per cent of corn flour was added to the wheat flour. In all cases the bread made from the flours containing increased or decreased quantities of starch was compared with that made from a like quantity of the normal flour.

There was practically no difference in either the size or appearance of the loaf as compared with that from normal flour. Similarly, little difference was observed between the bread and from normal flour and that from flour with the proportion of starch diminished. Experiments were also made to determine the relation between the nature of the gluten and the character of the bread. This was done by comparing bread from normal flour with that from other flour of the same lot, from which part or all of its gliadin had been extracted. Dough made from the latter was not sticky, but felt like putty, and broke in the same way. The yeast caused the mass to expand a little when first placed in the oven; then the loaf broke apart at the top and decreased in size. When baked it was less than half the size of that from the same weight of normal flour, and decidedly inferior in other respects. It was about as heavy as the same quantity of rubber. The removal of part of the gliadin produced nearly the same effect as the extraction of the whole of it, and even when an equal quantity of normal flour was mixed with that from which part of the gliadin had been extracted the bread was only slightly improved.

Some experiments have recently been made at the Ontario Agriculture College to determine what kinds of flours were best adapted to making milk biscuit with baking powder, and the conclusion reached that soft flours, i. e., those in which the gluten was not too strong, made biscuits that were tenderer and more easily handled than strong flours.

At the present prices of the different flours the strong wheat flour biscuits cost more than soft wheat flour biscuits. It is possible that a larger proportion of fat used with the strong wheat flour would yield biscuits of tenderness equal to those of soft wheat flour, but the cost of fat makes that method of improvement a disadvantage.

Grades of Flour.—There are several grades of flour obtained in milling the wheat. These are known as first and second patent, first and second clear grade and red-dog. The first patent is the highest grade of flour manufactured; the gluten in it has a greater power of expansion than that in any other grade, and the loaf made is the largest and whitest. Second patent is somewhat similar to first patent, but the gluten has not quite so high a power of expansion, and the bread is a shade darker. The first clear grade, which comprised about 12 per cent of the wheat, is obtained after the first and second patent have been removed. This grade contains slightly more protein than either of the two patent grades, but the gliadin and glutenin are not present in such favorable proportions for bread making. All three of these flours are combined to produce the straight or standard patent flour. The quantity of first or second patent flour put upon the market is relatively small compared with that of standard patent.

After the standard patent flour has been removed there is still obtained about 0.5 per cent of a flour called second clear, or low grade, which contains a high percentage of protein, but with a gluten of poor quality for bread making. Finally there is the so-called red-dog flour, the lowest grade produced, which is secured mainly from the germ or embryo and adjacent parts of the wheat. It contains large proportions of protein and fat, but the proteids of the wheat germ are decidedly different from gluten in character and composition. Germ flour has poor agglutinating properties, and little power of expansion, and produces a poorly raised, dark-colored loaf.

Pastry.—The soft flours are generally used for making pastry, and are, consequently, called pastry flour. It does not follow, however, that good pastry cannot be made from the stronger flours. In fact, it is possible; but more shortening must be used to get results obtainable from the softer winter wheat flour. The greater gluten content, expansive powers, and good color of the stronger flours are not necessary requisites for pastry purposes; and, consequently, it would not appear to be good practice to purchase these more expensive flours and then use larger quantities of shortening in order to obtain the same results that may be secured by the use of the cheaper flours and less shortening. Practically the matter resolves itself into one of cost.

Losses of Material in Bread Making.—In whatever way bread is made there is always some loss of materials in the process beyond that of the flour and dough accidentally lost in the mixing and molding, and these losses are especially noticeable in bread made with yeast. In experiments carried on at the Minnesota and New Jersey Agricultural Experiment Stations it has been estimated that anywhere from 1.5 to 8 per cent of the nutrients in the flour may disappear in this way. The yeast plants require a certain amount of nitrogenous material for their growth, but fortunately feed to some extent on other substances of less nutritive value than protein, and thus occasion only slight loss of valuable food material. A small proportion of the fats also disappear, probably volatilized by the heat of baking. The greatest loss occurs in the carbohydrates. It has been seen that during the process of fermentation part of the starch is changed to carbon dioxid and alcohol; in the later stages small amounts of volatile acids are also formed from the decomposition of carbohydrates. In tests in which care was taken to prevent loss the equivalent of 1.68 per cent of the carbohydrates was lost in this way. When bread is less carefully made the loss is likely to be much greater.

Of course part of these losses are inevitable, and the superior lightness, flavor, and keeping qualities of well-made yeast bread more than compensate for them. Evidently the art of producing a well-raised and at the same time the most nutritious loaf depends on letting the fermentation continue just long enough to avoid sogginess and heaviness, and no further.

Composition of Bread.—The composition of bread depends primarily upon that of the flour from which it is made. If milk and butter (or lard) are used in mixing the dough, as is commonly the case, their nutrients are, of course, added to those of the flour; but when only water and flour are used the nutrients of the bread are simply those of the flour. In either case, however, the proportions of the nutrients in the bread are smaller than those in the flour, because part of the moisture from the water or the milk used in mixing the dough is present in the bread after baking, that is, a pound of the bread would contain less of any of the nutrients than a pound of the flour.

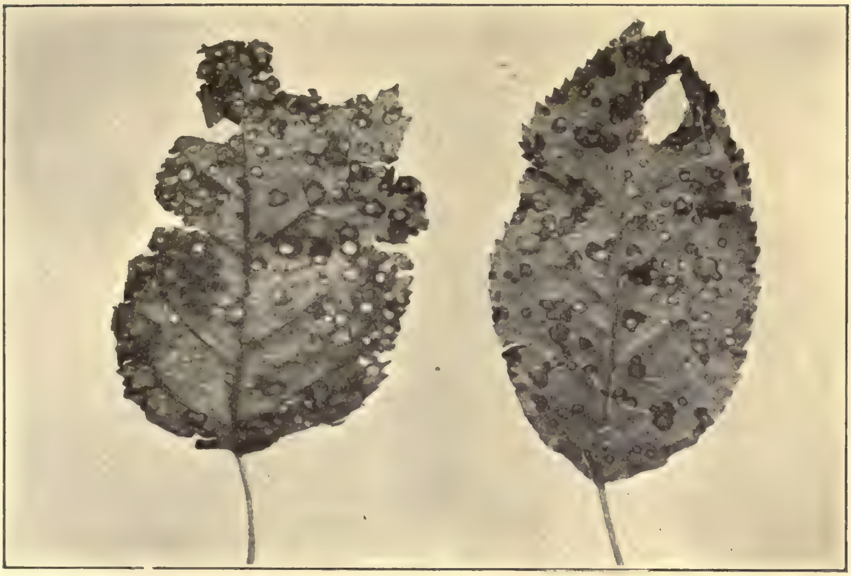
The breads from the different flours, made in such ways as to afford comparison, bear the same relation to one another as the flours in respect to the proportions of nutrients. Thus, in the breads made from different grades of patent flour, that from the high-grade flour, which had the lowest protein content, had the least protein, while that from low-grade flour, which is the richest in protein, had the most. Judged by their composition, all breads are nutritious foods, and too great stress should not be laid on the variations in composition between the different kinds.

Digestibility of Different Kinds of Bread.—A knowledge of the digestibility of any food material is of prime importance. The next question then is, What kind of bread furnishes the greatest amount of digestible nutrients? About 100 digestion experiments have been made with healthy young men with bread from all grades of flour ground from hard and soft wheats. The larger number of these experiments were made with Graham, entire wheat, and standard patent flours from wheats from different sections of the country. The averages of the results with these three grades of flour give the following as the proportions of nutrients that were digested from the different flours, these factors being commonly termed coefficients of digestibility: Standard patent flour, protein 88.6 per cent and carbohydrates 97.7 per cent; entire wheat flour, protein 82 per cent and carbohydrates 93.5 per cent; Graham flour, protein 74.9 per cent and carbohydrates 89.2 per cent.

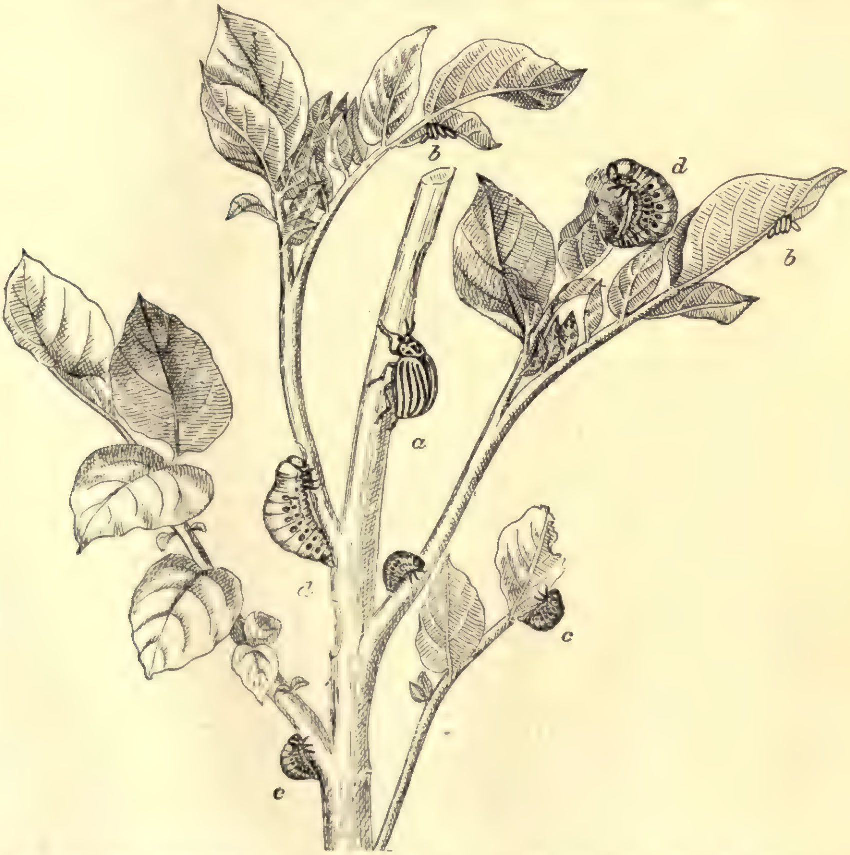
It will be seen that there is a considerable difference in the digestibility of the nutrients in the three kinds of bread, the variations in the protein being larger than those in the carbohydrates. For both nutrients the digestibility of the standard patent flour was the greatest, of entire wheat the next, and that of the Graham flour was least. This is true not only for the average of the tests with the different flours, but also for the individual tests.

Experiments were made with first, second, and standard patent flours to learn how these compare with one another, the digestibility of the nutrients as determined in these tests being as follows: First patent, protein 90.5 per cent and carbohydrates 98 per cent; second patent, protein 91.4 per cent and carbohydrates 98.7 per cent; standard patent, protein 90.3 per cent and carbohydrates 97.4 per cent. Practically, there was no difference in these three grades of patent flour with respect to the proportions digested; and since the proportion of protein is much the same in all of them, they are about equal in actual nutritive value.

The Nutritive Value of Bread.—Bread contains from 35 to 40 per cent of water. Since the remainder, about 60 per cent at least, is nutritive material, bread is really one of the most nutritious of the common foods, but few others equaling it in this respect. It supplies a large amount of carbohydrates, a moderate amount of protein, a small amount of mineral matters, and almost no fat. Since there is relatively an excess of carbohydrates and a deficiency of protein in wheat, bread could not serve alone for proper nutrition of the body, because an amount of bread sufficient to supply the requisite protein



Apple Leaves Showing Natural Infection. Dept. of Agr.



Colorado Potato Beetle at Work on the Plant; *A*. Beetle. *B*. Egg Masses; *C*. Half-Grown Larvae; *D*. Mature Larvae. Dept. of Agr.

would furnish much more carbohydrates than necessary. In a mixed diet this discrepancy is of little importance, because the deficiency of protein is made up by such foods as meat or cheese. Bread and milk forms a much more suitable diet than bread alone. A comparison of skim-milk bread with water bread made from the same flour, shows that the skim milk increased the protein to the extent of about 2 per cent.

Graham, Entire Wheat, and Standard Patent Flours.—The nutritive value of these three classes of flour and the breads made from them has been extensively investigated by Snyder at the Minnesota Agricultural Experiment Station and by Woods at the Maine Agricultural Experiment Station. Graham flour, strictly speaking, is simply wheat meal; that is, the entire grain ground to a powder. The term whole wheat or entire wheat seems rather inexact and suggests flour practically identical with the Graham. The flour thus designated, however, is said to be made often by removing the branny outer covering and grinding the remainder. The flour most widely used is that known as straight patent, or standard patent, or family grade. Although this flour contains neither the germ nor the bran of the wheat, in modern exhaustive milling nearly 73 per cent of the kernel is recovered in it.

All flours are wholesome and palatable. The housekeeper may therefore wisely use all the different kinds of flours to give variety to the diet and please the taste of different members of her family. As has been said, well-made bread of any kind is a very nutritious food, and the differences between the various kinds are too small to be of practical importance to persons of healthy digestions and comfortable circumstances.

As far as nutritive value is concerned the cheaper grades are fully as good as the more expensive. The bread made from them is as light as that from the finer flours, but not quite so white and appetizing. Where rigid economy is necessary the cheaper grades can safely be used.

Crackers, Macaroni, Cakes.—These made from white flour have also been tested at the Minnesota Experiment Station, and it has been found that their digestibility was practically the same as that of white bread. Nothing very definite has yet been learned about the ease and quickness with which these foods are digested. Bearing these limitations in mind, however, it may safely be said that simple, well-made crackers and cakes, at least when eaten in moderate quantities, are digested by persons in health with much the same thoroughness as bread.

Hot, Fresh, and Toasted Bread.—Statements of a popular nature are frequently met with regarding the unwholesomeness of hot bread. The fact that bread is hot has doubtless little to do with the matter. New bread, especially that from a large loaf, may be readily compressed into more or less solid masses, and it is possible that such bread would be much less finely masticated than crumbly, stale bread, and that, therefore, it might offer more resistance to the digestive juices of the stomach.

When bread is toasted the chemical nature of some of its ingredients is changed and the carbohydrates at least become more soluble and presumably more easily digested. The ferments and bacteria which may have survived the baking or which have entered the bread later are also killed if the toasting is continued long enough; this may be of considerable advantage to persons of delicate digestion. Owing to its dryness, toast is more likely to be well masticated than fresh bread. These facts and the further one that perhaps owing to its crispness and greater flavor it is often more appetizing than bread explain why toast is so suitable for invalids. Of course its advantages are greater when it has been well toasted throughout than when only the outer surfaces have been subjected to the action of the heat.

Cost of Bread.—Bread is a cheap nutritious food. Three pounds of flour will make four pounds of bread. If fire is kept just to bake the bread, the cost of fuel must be added to the cost of ingredients. It would seem that in the case of very poor families, an important pecuniary saving would result if bread was baked at home. To the man in ordinary circumstances it must be always more a question of convenience and taste than of cost. In short, each family can best determine whether it is desirable to pay the baker for the trouble of making the bread and delivering it or whether the labor of making and the extra fuel for baking can best be provided at home.—(Off. Exp. S. Bul. 101, 126, 156, 143; Dept. Agr. F. B. 193, 389; Dept. Agr. Year Book, 1903; Florida Exp. St. Bul. 52; Texas Exp. St. Bul. 91; Minn. Exp. St. Bul. 54; Cornell Rural Sch. Leaflet, Vol. 2, No. 8.)

COTTONSEED MEAL.

The agitation for the use of this substance as a human food has recently been extended and has attracted considerable attention. Cottonseed breads and other edibles made from cottonseed meal have been placed upon the market at Brenham, Longview, and especially at Ennis, Texas. Mrs. Dan McCarty, of Ennis, Texas, claims to be the first and only purveyor of cottonseed flour, bread and cakes, and her products have attracted considerable attention. The following products are being sold: Cottonseed bread, cottonseed rolls, cottonseed steamed bread, cottonseed ginger bread, cottonseed ginger snaps, cottonseed doughnuts, cottonseed Jeff Davis plum pudding.

Cottonseed flour is richer in protein than meat, and resembles meat more than it does wheat flour, rice, corn meal, or other vegetable food, therefore it could be used as a meat substitute. Either alone or mixed with wheat flour it can be used to prepare bread, ginger cakes, puddings, cakes, etc., which are appetizing and there is reason to believe it is wholesome when used in small amounts.

Being rich in protein it should not be consumed in such quantity as to make the diet one-sided, and too rich in protein. One must be careful not to over-eat it. When used as a meat substitute one ounce of meal equals two of meat. It can be used to reinforce the diet of those whose diet is deficient in protein. Cottonseed meal should always be mixed with not less than four parts flour or meal to one of cottonseed meal. It may not agree with some people. Every man must decide what food agrees with him; moldy or stale meal should of course never be used.

RECIPE FOR BREAD.

For one loaf of bread use ½ pint of water or milk; ¼ of a yeast cake, or ½ cup of liquid starter, and 1 teaspoonful of salt. If a crumbly crumb is liked, use 1 teaspoon to 1 tablespoon of lard or drippings or butter. If sweet bread is liked, use 1 teaspoon to 1 tablespoon of sugar. At first, use enough flour to make a batter (about 2 to 2½ cupfuls).

If milk is used, boil it up once, add salt, butter and sugar and then let it cool until it is about lukewarm. It is better to boil the water used for it may contain some living things harmful to the yeast. After the liquid has cooled, add the yeast and enough flour to make a batter and then beat it well to put in plenty of oxygen. Cover with a clean cloth and set in a warm place until light. If compressed yeast or "starter" is used the batter will be light in three or four hours. If dry yeast is used it will take at least over night for the yeast to get a good start. When the batter is light, add enough flour to make a dough and knead it until it is no longer sticky. Then put it back into the same bowl or pan in which the sponge was made and let it rise until it is a little more than double its bulk. Shape into a loaf, put into a buttered bread pan, and let it rise again until it has about doubled its size. It should feel light and very elastic. Bake at once in a moderately hot oven for 40 to 45 minutes. This will not make a very large loaf of bread.—(Cornell Rural School Leaflet Vol. 2, No. 9.)

CANNING VEGETABLES.

Every housewife may run a miniature canning factory in her own kitchen, and on the farm this is especially economical and desirable. Enough vegetables annually go to waste from the average farm garden to supply the table during the entire winter. But usually the farmer's wife cans her tomatoes, preserves her fruits, and leaves her most wholesome and nutritious vegetables to decay in the field, under the impression that it is impossible to keep them. This is a great mistake. It is just as easy to keep corn or string beans as it is to keep tomatoes, if you know how. The great secret of canning or preserving lies in complete sterilization. To sterilize a substance is to destroy all life or sources of life in or about it.

Germs which cause decay may be divided into three classes—yeasts, molds, and bacteria. All three of these are themselves plants of a very low order, and all attack other plants of a higher order in somewhat the same way. Every housewife is familiar with the yeast plant. Yeasts are easily killed, so they can be left out of consideration in canning vegetables. The spoiling of vegetables is due primarily to bacteria.

Bacteria are also much more resistant to heat than yeasts. They thrive in products like milk and in meats and vegetables rich in protein, such as peas, beans, etc. Certain species of bacteria will live and cause vegetables to decompose even when no air is present. Bacteria are so small that they can only be seen with a microscope, and they reproduce themselves with amazing rapidity.

The reproduction of bacteria is brought about by one of two processes. The germ either divides itself into two parts, making two bacteria where one existed before, or else reproduces itself by means of spores. These spores may be compared with seeds of an ordinary plant, and they present the chief difficulty in canning vegetables. While the parent bacteria may be readily killed at the temperature of boiling water, the seeds retain their vitality for a long time even at that temperature, and upon cooling will germinate, and the newly formed bacteria will begin their destructive work. Therefore it is necessary, in order to completely sterilize a vegetable, to heat it to the boiling point of water and keep it at that temperature for about one hour, upon two or three successive days, or else keep it at the temperature of boiling water for a long period of time—about five hours. The process of boiling upon successive days is the one that is always employed in scientific work and is much to be preferred. The boiling on the first day kills all the molds and practically all of the bacteria, but does not kill the spores or seeds.

As soon as the jar cools these seeds germinate and a fresh crop of bacteria begin work upon the vegetables. The boiling upon the second day kills this crop of bacteria before they have had time to develop spores. The boiling upon the third day is not always necessary, but is advisable in order to be sure that the sterilization is complete. Among scientists this is called fractional sterilization, and this principle constitutes the whole secret of canning. If the housewife will only bear this in mind she will be able with a little ingenuity to can any meat, fruit, or vegetable.

Exclusion of the Air.—Even after sterilization is complete the work is not yet done. It is necessary after sterilizing a jar of vegetables to exclude carefully all outside air. If one bacterium or one of its spores should get in and find a resting place, in the course of a few days the contents of the jar would spoil. All of this may seem new fashioned and unnecessary to some housekeepers, but in the end it pays.

The first requisite for successful canning is a good jar. Glass is best as none of the vegetable acids act upon it. With proper care glass jars will last a long time. The best has no metal top to wear out or corrode. The rubber ring and glass top are easy to sterilize and easy to put in place. There are several brands of them on the market. Vegetables often spoil after being sterilized because of defective rubbers. It is poor economy to buy cheap rubbers or to use them a second time. As a general rule black rubbers are more durable than white ones. Buy a good grade of jar. The initial expense may be high, but they should last many years. Select those having wide mouths. In canning whole fruit or vegetables and in cleaning the jars the wide mouth will be found to be decidedly preferable.

Containers for Sterilizing.—One person uses a tin clothes boiler with a false bottom made of wire netting cut to fit it. The netting is made of medium-sized galvanized wire with one-half inch mesh. A false bottom is absolutely necessary, as the jars will break if set flat upon the bottom of the boiler. Narrow strips of wood, straw, or almost anything of this nature may be used for the purpose, but the wire gauze is clean and convenient. There are several varieties of patent steamers or steam cookers in common use. These have either one or two doors and hold a dozen or more quart jars. They are ideal for canning, but they are somewhat expensive. A common ham boiler or clothes boiler with a tight-fitting cover will answer every purpose.

Selection and Preparation of Vegetables.—Never attempt to can any vegetable that has matured and commenced to harden or one that has begun to decay. Young vegetables are superior in flavor and texture to the more mature ones. This is especially true of string beans, okra, and asparagus. Vegetables are better if gathered in the early morning while the dew is still on them. If it is impossible to can them immediately, put them in cold water or in a cold, damp place and keep them crisp until you are ready for them. Do your canning in a well-swept and well-dusted room. This will tend to reduce the number of spores floating about and lessen the chances of inoculation. The principle of sterilization is the same for all meats, fruits, and vegetables.

Corn.—Contrary to the general opinion, corn is one of the easiest vegetables to can. The amount of sugar in the sweet varieties diminishes very rapidly after the ear is pulled; half of it is lost in twenty-four hours; therefore in order to retain the original sweetness and flavor, can corn within an hour if possible. Select the ears with full grains before they have begun to harden, as this is the period of greatest sugar content. Husk them and brush the silks off with a stiff brush. Shear off the grains with a sharp knife and pack the jar full. Add salt to taste, about a teaspoonful to the quart, and fill up the jar to the top with cold water. Put the rubber ring around the neck of the jar and place the glass top on loosely. Be careful not to press down the spring at the side of the jar.

Place the false bottom in the boiler and put in as many jars as the boiler will conveniently hold. Leave space between them. Pour in about 3 inches of cold water, or just enough to form steam and to prevent the boiler from going dry during the boiling. It is not necessary to have the water up to the neck of the jars, as the steam will do the cooking. Put the cover on the boiler and set it on the stove. Bring the water to a boil and keep it boiling for one hour. At the end of that time remove the cover of the boiler and allow the steam to escape. Press down the spring at the side of the jar. This clamps on the top and will prevent any outside air from entering. The jars can now be removed and cooled or allowed to stand in the boiler until the next day.

On the second day raise the spring at the side of the jar. This will relieve any pressure from steam that might accumulate inside the jar during the second cooking. Place the jars again in the boiler and boil for one hour. Clamp on the top as on the preceding day and allow them to cool. Repeat this operation on the third day. In removing the jars from the boiler be careful not to expose them to a draft of cold air while they are hot, as a sudden change in temperature is likely to crack them.

After the sterilization is complete the jars may be set aside for a day or two and then tested. This is done by releasing the spring at the side and picking up the jar by the top. If there has been the least bit of decomposition, or if sterilization has not been complete, the top will come off, because the pressure on the top has been relieved by the gas formed by the bacteria. In this case it is always best to empty out the corn and fill up the jar with a fresh supply. If canning fruits or some expensive vegetable, however, examine the contents of the jar and, if the decomposition has not gone far enough to injure the flavor, place it once more in the boiler and sterilize again. If the top does not come off, one may be reasonably sure that the corn is keeping. Corn is often subject to the attack of anaerobic bacteria. The spores of these are sometimes very hard to kill and remain alive even after boiling for one hour. In case any jars spoil, increase the time of boiling to an hour and a half.

String Beans.—Select young and tender beans, string them, and break them into short lengths. Pack firmly in the jar, cover with cold water, and add a teaspoon of salt to each quart. Put on the rubber and top and boil for one hour on each of three successive days, as directed under Corn. A small pod of red pepper placed in the bottom of the jar will give a delightful flavor to this vegetable.

Eggplant.—Pare the eggplant, cut in thin slices, and drop in boiling water for fifteen or twenty minutes. Drain off the water and pack the slices in the jar. Cover with water and sterilize as directed under Corn. The slices of eggplant are pliable and may be taken from the jar without being broken and either fried in bread crumbs or made into pudding and baked.

Summer Squash.—Cut the vegetable into small blocks, pack in the jars, and cover with water. Add a teaspoon of salt to each quart and sterilize. It is sometimes preferable with this vegetable, however, to pare off the skin, boil or steam until thoroughly done, mash them, and then pack in the jars and sterilize. If canned in the latter way, it is advisable to steam them for an hour and a half, instead of for an hour, on each of three days, as the heat penetrates the jar very slowly. It is absolutely necessary that the interior of the jar should reach the temperature of boiling water. A jar will usually hold about twice as much of the cooked vegetables as it will of the uncooked.

Tomatoes.—Every housewife knows how to can tomatoes. They are very easily kept, even in the common screw-top jar. When the tomato is to be used for food, care should be taken to retain all of the juice, as the nutrients are present largely in soluble form, and any diminution of the amount of juice entails a corresponding loss of nutrients. In the canning of tomatoes it is sometimes customary to allow the juice to drain from the solids, with the object of securing a more concentrated product. In order to determine the losses by this method of preservation, two cans were prepared, one with and one without the juice. An unnecessary loss of 22 per cent of the total sugar of the tomato resulted from the exclusion of the juices.

Others.—Beets, okra, or gumbo, peas, asparagus, cauliflower, carrots, parsnips, kohl-rabi, lima beans, pumpkins, winter squash and succotash have all been successfully canned.

VEGETABLE ROAST.

A rather unusual dish for the winter may be made by canning a mixture of vegetables. Prepare corn, lima beans, tomatoes, string beans, okra, squash, and eggplant as you would for canning separately. Mix these in varying proportions, letting the corn and lima beans predominate. Add two or three medium-sized onions to each quart of this mixture and run all through a food chopper in order to mix it thoroughly. Pack into jars and sterilize. In preparing for the table mix with an equal volume of bread crumbs, a piece of butter the size of a walnut, and one egg; season to taste with pepper and salt, and bake in a round baking dish until brown. Cut into slices as you would a cake and serve hot with a drawn butter sauce. Corn, okra, and tomatoes, mixed in equal proportions, may be canned in this way as a soup stock.

Freshness of Flavor and Color.—Vegetables when canned properly should retain their attractive color and lose very little of their flavor. The volatile oils which give flavor to most vegetables are not lost during this process of sterilization. Cooking for three short periods in a closed container at a comparatively low temperature instead of cooking for one short period at a high temperature or for one long period in an open vessel makes the vital difference and insures freshness of flavor and color. After the jars have been sterilized and tested, they should be kept in the dark, as the sunlight will soon destroy the color of the vegetable.

How to Open a Jar.—Jars of vegetables are sometimes hard to open, unless it is done in just the right way. Run a thin knife blade under the rubber, next to the jar, and press against it firmly. This will usually let in enough air to release the pressure on the top. In case it does not, place the jar in a deep saucepan of cold water, bring to a boil, and keep it boiling for a few minutes. The jar will then open easily.

Cautions.—These directions for canning apply only to pint and quart jars. If half-gallon jars are used, always increase the time of boiling, making it an hour and a half instead of an hour. Do not go into canning too deeply at first. Experiment with a few jars in the early part of the season and see if they keep well. If you follow the directions here given carefully, you will have no difficulty whatever. If you should happen to fail in the first trial, rest assured that you have done something wrong or left something undone. No housewife who has on hand during the winter a supply of home-canned vegetables ready to serve on ten minutes' notice will ever regret the trouble or difficulties experienced in learning.—(Dept. Agr. F. B. 359; Minn. Exp. Sta. B. 63.)

CANNING AND PRESERVING FRUIT.

Fruit has great dietetic value and should be used generously and wisely, both fresh and cooked. Fruits supply a variety of flavors, sugar, acids, and a necessary waste or bulky material for aiding in intestinal movement. They are generally rich in potash and soda salts and other minerals. Most fresh fruits are cooling and refreshing. The vegetable acids have a solvent power on the nutrients and are an aid to digestion when not taken in excess. Fruit and fruit juices keep the blood in a healthy condition when the supply of fresh meat, fish, and vegetables is limited. Fresh fruit is generally more appetizing and refreshing than cooked and eaten ripe and in moderate quantities rarely hurts anyone.

Cooking changes the character and flavor of fruit, and while the product is not so cooling and refreshing, it can, as a rule, be eaten with less danger of causing stomach or intestinal trouble. If sugar be added to the cooked fruit, the nutritive value will be increased. A large quantity of sugar spoils the flavor of the fruit and is likely to make it less easily digested.

Nowhere is there greater need of a generous supply of fruit than on the farm, where the diet is apt to be restricted in variety because of the distance from markets. Every farmer should raise a generous supply of the kinds of fruit that can be grown in his locality. Wives and daughters on the farms should find pleasure in serving these fruits in the most healthful and tempting form. There are a large number of simple, dainty desserts that can be prepared with fruit and without much labor. Such desserts should leave the pie as an occasional luxury instead of allowing it to be considered a daily necessity.

In the season when each kind of fruit is plentiful and at its best a generous supply should be canned for the season when both fruit and fresh vegetables are scarce. A great deal should be canned with little or no sugar, that it may be so nearly as possible in the condition of fresh fruit. This is the best condition for cooking purposes. If there be an abundance of grapes and small, juicy fruits, plenty of juice should be canned or bottled for refreshing drinks throughout the year. Fruit and juice are not luxuries, but an addition to the dietary that will mean better health for the members of the family and greater economy in the cost of the table.

Malic acid is the chief sour principle of apples, currants, gooseberries, plums, cherries, strawberries and most common fruits. It is abundant in rhubarb.

Most fruits are unfavorable to the growth of bacteria, but may be attacked by yeasts and molds. Yeasts may be destroyed by boiling fruits and their juices ten to fifteen minutes. Every housekeeper is familiar with molds. They develop from spores. The precautions given under canning vegetables should be followed with fruit.

They should be sealed from the air unless preserved with a large quantity of sugar, and all of them, preserves, jellies, jams or marmalade should be protected from molds. In canning fruits the product is better if heated gradually to the boiling point and then cooked the given time.

Utensils Needed for Canning and Preserving.—In preserving, canning, and jelly making iron or tin utensils should never be used. The fruit acids attack these metals and so give a bad color and metallic taste to the products. The preserving kettles should be porcelain lined, enameled, or of a metal that will not form troublesome chemical combinations with fruit juices. The kettles should be broad rather than deep, as the fruit should not be cooked in deep layers. A list of the most essential articles follows:

Two preserving kettles, 1 colander, 1 fine strainer, 1 skimmer, 1 ladle, 1 large-mouthed funnel, 1 wire frying basket, 1 wire sieve, 4 long-handled wooden spoons, 1 wooden masher, a few large pans, knives for paring fruit (plated if possible), flat-bottomed clothes boiler, wooden or willow rack to put in the bottom of the boiler, iron tripod or ring, squares of cheese-cloth. In addition, it would be well to have a flannel straining bag, a frame on which to hang the bag, a sirup gauge and a glass cylinder, a fruit pricker, and plenty of clean towels.

The regular kitchen pans will answer for holding and washing the fruit. Mixing bowls and stone crocks can be used for holding the fruit juice and pared fruit. When fruit is to be plunged into boiling water for a few minutes before paring, the ordinary stewpans may be employed for this purpose.

Scales are a desirable article in every kitchen, as weighing is much more accurate than the ordinary measuring.

If canning is done by the oven process, a large sheet of asbestos, for the bottom of the oven, will prevent the cracking of jars.

The wire basket is a saver of time and strength. The fruit to be peeled is put into the basket, which is lowered into a deep kettle partially filled with boiling water. After a few minutes the basket is lifted from the boiling water, plunged for a moment into cold water, and the fruit is ready to have the skin drawn off. A strong wire sieve is a necessity when purees of fruit are to be made. These sieves are known as puree sieves. They are made of strong wire and in addition have supports of still stronger wire. A fruit pricker is easily made and saves time. Cut a piece half an inch deep from a broad cork; press through this a dozen or more coarse darning needles; tack the cork on a piece of board. Strike the fruit on the bed of needles, and you have a dozen holes at once. A little oil on the needles will prevent rusting.

A wooden vegetable masher is indispensable when making jellies and purees. A sirup gauge and glass cylinder are valuable aids in getting the right proportion of sugar for fruit or jelly. The sirup gauge costs about 50 cents and the cylinder about 25 cents. A lipped cylinder that holds a little over a gill is the best size. Small iron rings, such as some times come off the hub of cart wheels, may be used instead of a tripod for slightly raising the preserving kettles from the hot stove or range. To make a flannel straining bag, take a square piece of flannel (27 by 27 inches is a good size), fold it to make a three-cornered bag, stitch one of the sides, cut the top square across, bind the opening with strong, broad tape, stitch on this binding four tapes with which to tie the bag to a frame. A high stool turned upside down makes a good support for the bag. The fruit juice, which will pass through this will be comparatively clear. Before it is used the bag should be washed and boiled in clear water.

Selection and Preparation of the Fruit.—The flavor of fruit is not developed until it is fully ripe; fruit is at its best for canning, jelly making, etc., just before it is perfectly ripe. In all soft fruits the fermentative stage follows closely upon the perfectly ripe stage. This is especially important in jelly making for in overripe fruit the pectin begins to lose its jelly-making quality. All fruits should be freshly picked. No imperfect fruit should be canned or preserved. Gnarly fruit may be used for jellies or marmalades by cutting out defective portions. Bruised spots should be cut out of peaches and pears. In selecting small-seeded fruits, like berries, for canning, those having a small proportion of seed to pulp should be chosen. The fruit should be rubbed through a sieve that is fine enough to keep back the seeds. When fruit is brought into the house put it where it will keep cool and crisp until you are ready to use it. System will do much to lighten the work. Have plenty of hot water and pans in which jars and utensils may be sterilized. Have at hand all necessary utensils, towels, sugar, etc.

Prepare only as much fruit as can be cooked while it still retains its color and crispness. Before beginning to pare fruit have some sirup ready, if that is to be used, or if sugar is to be added to the fruit have it weighed or measured. Decide upon the amount of fruit you will cook at one time, then have two bowls—one for the sugar and one for the fruit—that will hold just the quantity of each. As the fruit is pared or hulled, drop it into its measuring bowl. When the measure is full put the fruit and sugar in the preserving kettle. While this is cooking another measure may be prepared and put in the second preserving kettle. In this way the fruit is cooked quickly and put in the jars and sealed at once, leaving the pans ready to sterilize another set of jars.

If the fruit is to be preserved or canned with sirup, it may be put into the jars as fast as it is prepared. As soon as a jar is full, pour in enough sirup to cover it.

Where fruit (like quinces and hard pears) must be first boiled in clear water, the pared fruit should be dropped into a bowl of cold water made slightly acid with lemon juice (one tablespoonful of lemon juice to a quart of water) to keep the fruit white. All large, hard fruit must be washed before paring. Quinces should be rubbed with a coarse towel before they are washed. If berries must be washed, do the work before stemming or hulling them. Put a small quantity into a colander and pour cold water over them; then turn them on a sieve to drain. Work quickly that the fruit may not absorb much water. Do not use the fingers for hulling strawberries. A simple huller can be bought for five cents.

If practicable pare fruit with a silver knife, so as not to stain or darken the product. The quickest and easiest way to peel peaches is to drop them into boiling water for three minutes in a wire basket. Then plunge the basket into a pan of cold water, drain a minute, then peel. Plums and tomatoes may be peeled in the same manner. If the peaches are to be canned in sirup, put them at once into the sterilized jars. They may be canned whole or in halves. If in halves, remove nearly all the stones or pits. For the sake of the flavor, a few stones would be put in each jar. When preparing cherries, plums, or crab apples for canning or preserving, the stem or a part of it may be left on the fruit.

When preparing to make jelly have ready the cheese-cloth strainer, enameled colander, wooden spoons, vegetable masher, measures, tumblers, preserving kettles, and sugar. If currant jelly is to be made, free the fruit from leaves and large stems. If the jelly is to be made from any of the other small fruits, the stems and hulls must be removed.

When the jelly is to be made from any of the large fruits have the fruit washed clean, then remove the stem and the blossom end. Nearly all the large fruits are better for having the skin left on. Apples and pears need not be cored. There is so much gummy substance in the cores of quinces that it is best not to use this portion in making fine jelly.

Making Sirup for Use in Canning and Preserving.—Such sirups as are used in canning and preserving are made with varying proportions of water and sugar. When the proportion of sugar is large and that of the water small the sirup is said to be heavy. When the water predominates the sirup is light. There are several methods of measuring the proportion of sugar in a sirup. The most scientific and accurate is with the sirup gauge.

One pint sugar and 1 gill of water gives sirup of 40° density: Use for preserved strawberries and cherries.

One pint sugar and one-half pint water gives sirup of 32° density.

One pint sugar and 3 gills water gives sirup of 28° density: Use either this or the preceding for preserved peaches, plums, quinces, currants, etc.

One pint sugar and 1 pint water gives sirup of 24° density: Use for canned acid fruits.

One pint sugar and 1½ pints water gives sirup of 17° density.

One pint sugar and 2 pints water gives sirup of 14° density: Use either of these two light sirups for canned pears, peaches, sweet plums, and cherries, raspberries, blueberries, and blackberries.

The lightest sirups may be used for filling up the jars after they are taken from the oven or boiler. The process of making a sirup is very simple. Put the sugar and water in the saucepan and stir on the stove until all the sugar is dissolved. Heat slowly to the boiling point and boil gently without stirring. All sirups are better for boiling from ten to thirty minutes. If rich sirups are boiled hard, jarred, or stirred they are apt to crystallize. The sirup may be made a day or two in advance of canning time. The light sirups will not keep long unless sealed, but the heavy sirups keep well if covered well.

Use of the Sirup Gauge.—The sirup gauge is a graduated glass tube, with a weighted bulb, that registers from 0° 50°, and that is employed to determine the quantity of sugar contained in a sirup.

If this gauge is placed in pure water the bulb will rest on the bottom of the cylinder or other container. If sugar be dissolved in the water the gauge will begin to float. The more sugar there is dissolved in the water the higher the gauge will rise. The sirup should be deep enough to reach the zero point of the gauge. If a glass cylinder holding about half a gill is filled to about two-thirds its height, and the gauge is then placed in the cylinder, the quantity of sugar in the sirup will be registered on the gauge.

Experiments have demonstrated that when sugar is dissolved and heated in fruit juice, if the sirup gauge registers 25°, the proportion of sugar is exactly right for combining with the pectin bodies to make jelly. The sirup gauge and the glass cylinder must both be heated gradually that the hot sirup may not break them. If the gauge registers more than 25°, add a little more fruit juice. If it registers less than 25°, add more sugar. In making sirups for canning and preserving fruits, the exact amount of sugar in a sirup may be ascertained at any stage of boiling, and the sirup be made heavier by adding sugar, or lighter by adding water, as the case demands.

Canning Fruit.—This is the easiest and commonly considered the most economical and the best method of preserving it, because the fruit is kept in a soft and juicy condition in which it is believed to be easily digested. The wise housekeeper will can her principal fruit supply, making only enough rich preserves to serve for variety and for special occasions.

The success of canning depends upon absolute sterilization. If the proper care is exercised there need be no failure, except in rare cases, when a spore has developed in the can. There are several methods of canning; and while the principle is the same in all methods, the conditions may make one method more convenient than another. For this reason three will be given which are considered the best and easiest. These are: Cooking the fruit in the jars in an oven; cooking the fruit in the jars in boiling water; and stewing the fruit before it is put in the jars. The quantity of sugar may be increased if the fruit is liked sweet.

It is most important that the jars, covers, and rubber rings be in perfect condition.

Stewing and Canning.—Have two pans partially filled with cold water. Put some jars in one, laying them on their sides, and some covers in the other. Place the pans on the stove where the water will heat and boil at least ten or fifteen minutes. Have on the stove a shallow milk pan in which there is about 2 inches of boiling water. Sterilize the cups, spoons, and funnel, by immersing in boiling water for a few minutes. When ready to put the prepared fruit in the jars slip a broad skimmer under a jar and lift it and drain free of water. Set the jar in the shallow milk pan and fill to overflowing with the boiling fruit. Slip a silver-plated knife or the handle of a spoon around the inside of the jar, that the fruit and juice may be packed solidly. Wipe the rim of the jar, dip the rubber ring in boiling water and put it smoothly on the jar, then put on the cover and fasten. Place the jar on a board and out of a draft of cold air. The work of filling and sealing must be done rapidly, and the fruit must be boiling hot when it is put into the jars. If screw covers are used, it will be necessary to tighten them after the glass has cooled and contracted. When the fruit is cold wipe the jars with a wet cloth, and put away in a cool, dark closet.

In canning, any proportion of sugar may be used, or fruit may be canned without the addition of any sugar. Sauce should have the sugar cooked with it. Juicy fruits, such as berries and cherries, require little or no water. Strawberries are better not to have water added to them. The only exception to this is when they are cooked in a heavy sirup.

Raspberries.—12 quarts of raspberries; 2 quarts of sugar.

Put 2 quarts of the fruit in the preserving kettle; heat slowly on the stove; crush with a wooden vegetable masher; spread a square of cheese cloth over a bowl, and turn the crushed berries and juice into it. Press out the juice, which turn into the preserving kettle. Add the sugar and put on the stove; stir until the sugar is dissolved. When the sirup begins to boil, add the remaining 10 quarts of berries. Let them heat slowly. Boil ten minutes, counting from the time they begin to bubble. Skim well while boiling. Put in cans and seal as directed.

Rhubarb.—Cut the rhubarb when it is young and tender. Wash it thoroughly and then pare; cut into pieces about 2 inches long. Pack in sterilized jars. Fill the jars to overflowing with cold water and let them stand ten minutes. Drain off the water and fill again to overflowing with fresh cold water. Seal with sterilized rings and covers. When required for use, treat the same as fresh rhubarb. Green gooseberries may be canned in the same manner. Both may be cooked and canned with sugar.

Canned Fruit Cooked in the Oven.—This method of canning fruit is sometimes to be preferred. The work is easily and quickly done, and the fruit retains its shape, color, and flavor better than when cooked in the preserving kettle. Cover the bottom of the oven with a sheet of asbestos, the kind plumbers employ in covering pipes. It is very cheap and may usually be found at plumbers' shops. If the asbestos is not available, put into the oven shallow pans in which there are about two inches of boiling water.

Sterilize the jars and utensils. Make the sirup; prepare the fruit the same as for cooking in the preserving kettle. Fill the hot jars with it, and pour in enough sirup to fill the jar solidly. Run the blade of a silver-plated knife around the inside of the jar. Place the jars in the oven, either on the asbestos or in the pan of water. The oven should be moderately hot. Cook the fruit ten minutes; remove from the oven and fill the jar with boiling sirup. Wipe and seal. Place the jars on a board and out of a draft of air. If the screw covers are used tighten them after the glass has cooled. Large fruits, such as peaches, pears, quinces, crab apples, etc., will require about a pint of sirup to each quart jar of fruit. The small fruit will require a little over half a pint of sirup. The amount of sugar in each quart of sirup should be regulated to suit the fruit with which it is to be used. The quantity of sugar may be increased or diminished to suit the taste.

Canned Fruit Cooked in a Water Bath.—Prepare the fruit and sirup as for cooking in the oven. Fill the sterilized jars and put the covers on loosely. Place in boiler as directed for canning vegetables. Cover the boiler and let the fruit cook ten minutes from the time the water surrounding it begins to boil. Draw the boiler back and take off the cover. When the steam passes off take out one jar at a time and place in a pan of boiling water beside the boiler, fill up with boiling sirup, and seal. Put the jars on a board and do not let cold air blow upon them. If screw covers are used tighten them when the glass has cooled and contracted.

Preserving Fruit.—In the case of most fruits, canning with a little sugar is to be preferred to preserving with a large quantity of sugar. There are, however, some fruits that are only good when preserved. Such preparations of fruit are only desirable for occasional use. The fruits best adapted for preserving are strawberries, sour cherries, sour plums, and quinces. Such rich preparations should be put up in small jars or tumblers.

Fruit Purées.—These are in the nature of marmalades, but they are not cooked so long, and so retain more of the natural flavor of the fruit. This is a particularly nice way to preserve the small, seedy fruits, which are to be used in puddings, cake, and frozen desserts.

Free the fruit from leaves, stems, and decayed portions. Peaches and plums should have the skins and stones removed. Rub the fruit through a purée sieve. To each quart of the strained fruit add a pint of sugar. Pack in sterilized jars. Put the covers loosely on the jars. Place the jars on the rack in the boiler. Pour in enough cold water to come half way up the sides of the jars. Heat gradually to the boiling point and boil thirty minutes, counting from the time when the water begins to bubble. Have some boiling sirup ready. As each jar is taken from the boiler put it in a pan of hot water and fill up with the hot sirup. Seal at once.

Marmalades.—These require great care while cooking because no moisture is added to the fruit and sugar. If the marmalade is made from berries the fruit should be rubbed through a sieve to remove the seeds. If large fruit is used have it washed, pared, cored.

and quartered. Measure the fruit and sugar, allowing one pint of sugar to each quart of fruit.

Rinse the preserving kettle with cold water that there may be a slight coat of moisture on the sides and bottom. Put alternate layers of fruit and sugar in the kettle, having the first layer fruit. Heat slowly, stirring frequently. While stirring, break up the fruit as much as possible. Cook about two hours, then put in small sterilized jars.

Fruit Preserved in Grape Juice.—Any kind of fruit can be preserved by this method, but it is particularly good for apples, pears, and sweet plums. No sugar need be used in this process. Boil 6 quarts of grape juice in an open preserving kettle, until it is reduced to 4 quarts. Have the fruit washed and pared, and, if apples or pears, quartered and cored. Put the prepared fruit in a preserving kettle and cover generously with the boiled grape juice. Boil gently until the fruit is clear and tender, then put in sterilized jars.

Boiled Cider.—When the apple crop is abundant and a large quantity of cider is made, the housekeeper will find it to her advantage to put up a generous supply of boiled cider. Such cider greatly improves mincemeat, and can be used at any time of the year to make cider apple sauce. The cider must be perfectly fresh and sweet. Put it in a large, open preserving kettle and boil until it is reduced one-half. · Skim frequently while boiling. Do not have the kettle more than two-thirds full. Put in bottles or stone jugs.

METHODS OF MAKING JELLY.

In no department of preserving does the housekeeper feel less sure of the result than in jelly making. The rule that works perfectly one time fails another time. Why this is so the average housekeeper does not know. These two questions are being constantly asked: Why does not my jelly harden? What causes my jelly to candy?

It is an easy matter to say that there is something in the condition of the fruit, or that the fruit juice and sugar were cooked too short or too long a time. These explanations are often true; but they do not help the inquirer, since at other times just that proportion of sugar and time of cooking have given perfect jelly. In the following pages an attempt is made to give a clear explanation of the principles underlying the process of jelly making.

Pectin, Pectose, Pectase.—In all fruits, when ripe or nearly so, there is found pectin, a carbohydrate somewhat similar in its properties to starch. It is because of this substance in the fruit juice that we are able to make jelly. When equal quantities of sugar and fruit juice are combined and the mixture is heated to the boiling point for a short time, the pectin in the fruit gelatinizes the mass.

It is important that the jelly maker should understand when this gelatinizing agent is at its best. Pectose and pectase always exist in the unripe fruit. As the fruit ripens the pectase acts upon the pectose, which is insoluble in water, converting it into pectin, which is soluble. Pectin is at its best when the fruit is just ripe or a little before. If the juice ferments, or the cooking of the jelly is continued too long, the pectin undergoes a change and loses its power of gelatinizing. It is, therefore, of the greatest importance that the fruit should be fresh, just ripe or a little underripe, and that the boiling of the sugar and juice should not be continued too long.

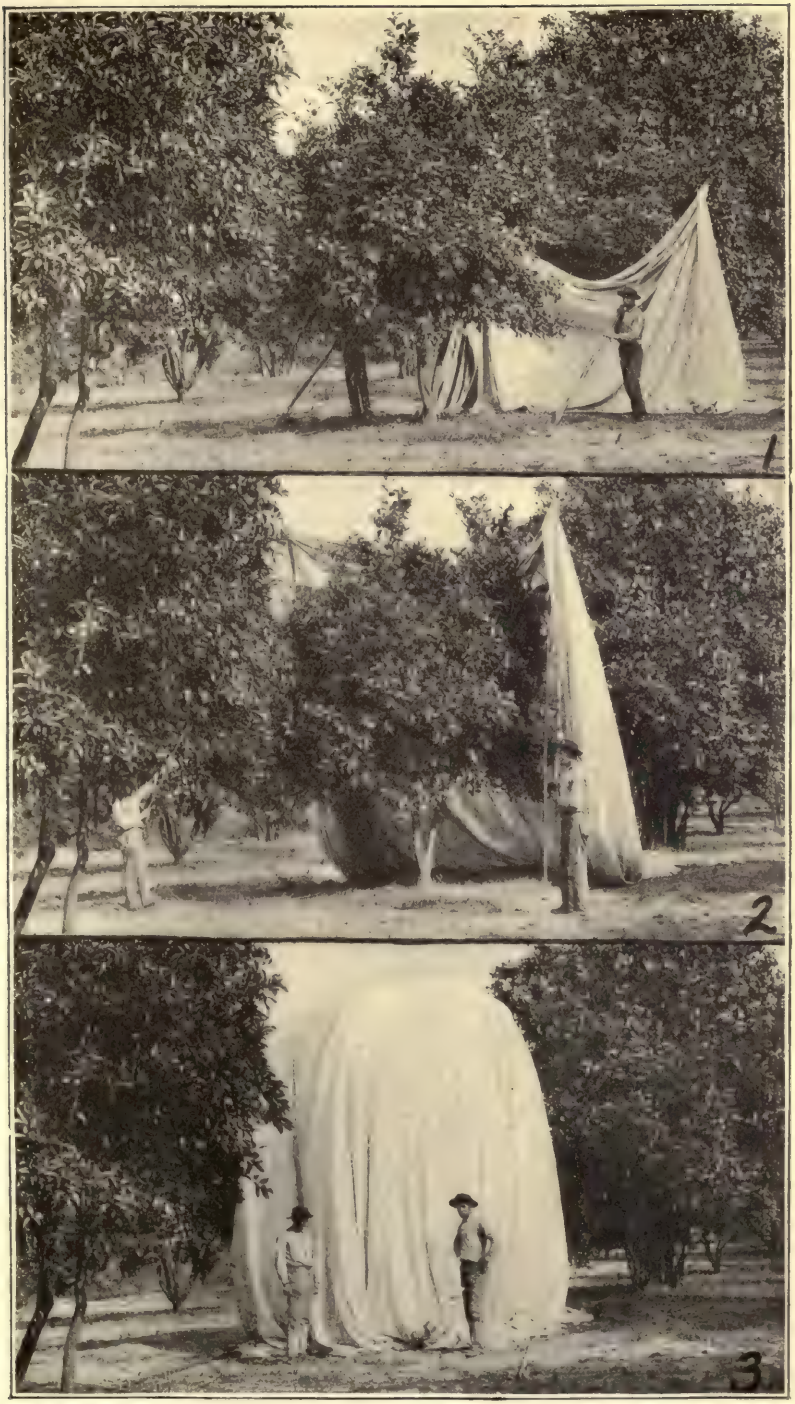
Fruits vary as to the quantities of sugar, acid, pectin, and gums in their composition. Some of the sour fruits contain more sugar than do some of the milder-flavored fruits. Currants, for example, often contain four or five times as much sugar as the peach. The peach does not contain so much free acid and it does contain a great deal of pectin bodies, which mask the acid; hence, the comparative sweetness of the ripe fruit.

Selection and Handling of Fruit For Jelly Making.—An acid fruit is the most suitable for jelly making, though in some of the acid fruits, the strawberry, for example, the quantity of the jelly-making pectin is so small that it is difficult to make jelly with this fruit. If, however, some currant juice be added to the strawberry juice, a pleasant jelly will be the result; yet, of course, the flavor of the strawberry will be modified. Here is a list of the most desirable fruits for jelly making. The very best are given first: Currant, crab apple, apple, quince, grape, blackberry, raspberry, peach.

Apples make a very mild jelly, and it may be flavored with fruits, flowers, or spices. If the apples are acid it is not advisable to use any flavor. Juicy fruits, such as currants, raspberries, etc., should not be gathered after a rain, for they will have absorbed so much water as to make it difficult, without excessive boiling, to get the juice to jelly. If berries are sandy or dusty it will be necessary to wash them, but the work should be done very quickly so that the fruit may not absorb much water. Large fruits, such as apples, peaches, and pears, must be boiled in water until soft. The strained liquid will contain the flavoring matter and pectin.

It requires more work and skill to make jellies from the fruits to which water must be added than from the juicy fruits. If the juicy fruits are gathered at the proper time one may be nearly sure that they contain the right proportion of water. If gathered after a rain the fruit must be boiled a little longer that the superfluous water may pass off in steam. In the case of the large fruits a fair estimate is 3 quarts of strained juice from 8 quarts of fruit and about 4 quarts of water. If the quantity of juice is greater than this it should be boiled down to 3 quarts. Apples will always require 4 quarts of water to 8 quarts of fruit, but juicy peaches and plums will require only 3 or 3½ quarts. The jelly will be clearer and firmer if the fruit is simmered gently and not stirred during the cooking.

It is always best to strain the juice first through cheese cloth and without pressure. If the cloth is double the juice will be quite clear. When a very clear jelly is desired the strained juice should pass through a flannel or felt bag. The juice may be pressed from the fruit left in the strainer and used in marmalade or for a second-quality jelly.



Covering Small Tree with Sheet Tent and Poles. Dept. of Agr.

To make jelly that will not crystallize (candy) the right proportion of sugar must be added to the fruit juice. If the fruit contains a high percentage of sugar, the quantity of added sugar should be a little less than the quantity of fruit juice. That is to say, in a season when there has been a great deal of heat and sunshine there will be more sugar in the fruit than in a cold, wet season; consequently, 1 pint of currant juice will require but three-quarters of a pint of sugar. But in a cold, wet season the pint of sugar for the pint of juice must be measured generously. Another cause of the jelly crystallizing is hard boiling. When the sirup boils so rapidly that particles of it are thrown on the upper part of the sides of the preserving kettle they often form crystals. If these crystals are stirred into the sirup they are apt to cause the mass to crystallize in time.

The use of the sirup gauge and care not to boil the sirup too violently would do away with all uncertainty in jelly making. The sirup gauge should register 25°, no matter what kind of fruit is used. Jellies should be covered closely and kept in a cool, dry, dark place.

Currant Jelly.—The simplest method of making currant jelly is perhaps the following: Free the currants from leaves and large stems. Put them in the preserving kettle; crush a few with a wooden vegetable masher or spoon; heat slowly, stirring frequently.

When the currants are hot, crush them with the vegetable masher. Put a hair sieve or strainer over a large bowl; over this spread a double square of cheese cloth. Turn the crushed fruit and juice into the cheese cloth, and let it drain as long as it drips, but do not use pressure. To hasten the process take the corners of the straining cloth firmly in the hands and lift from the sieve; move the contents by raising one side of the cloth and then the other. After this put the cloth over another bowl. Twist the ends together and press out as much juice as possible. This juice may be used to make a second quality of jelly.

The clear juice may be made into jelly at once, or it may be strained through a flannel bag. In any case, the method of making the jelly is the same. Measure the juice, and put it in a clean preserving kettle. For every pint of juice add a pint of granulated sugar.

Stir until the sugar is dissolved, then place over the fire; watch closely, and when it boils up draw it back and skim; put over the fire again, and boil and skim once more; boil and skim a third time; then pour into hot glasses taken from the pan of water on the stove and set on a board. Place the board near a sunny window in a room where there is no dust. It is a great protection and advantage to have sheets of glass to lay on top of the tumblers. As soon as the jelly is set cover by one of the three methods given.

To make very transparent currant jelly, heat, crush, and strain the currants as directed in the simplest process. Put the strained juice in the flannel bag and let it drain through. Measure the juice and sugar, pint for pint, and finish as directed above.

To make currant jelly by the cold process follow the first rule for jelly as far as dissolving the sugar in the strained juice. Fill warm, sterilized glasses with this. Place the glasses on a board and put the board by a sunny window. Cover with sheets of glass and keep by the window until the jelly is set. The jelly will be more transparent if the juice is strained through the flannel bag. Jelly made by the cold process is more delicate than that made by boiling, but it does not keep quite so well.

Covering Jellies.—Jellies are so rich in sugar that they are protected from bacteria and yeasts, but they must be covered carefully to protect them from mold spores and evaporation. The following methods of covering jellies are all good:

Have disks of thick white paper the size of the top of the glass. When the jelly is set, brush the top over with brandy or alcohol. Dip a disk of paper in the spirits and put it on the jelly. If the glasses have covers, put them on. If there are no covers, cut disks of paper about half an inch in diameter larger than the top of the glass. Beat together the white of one egg and a tablespoonful of cold water. Wet the paper covers with this mixture and put over the glass, pressing down the sides well to make them stick to the glass; or the covers may be dipped in olive oil and be tied on the glasses, but they must be cut a little larger than when the white of egg is used.

A thick coating of paraffin makes a good cover, but not quite so safe as the paper dipped in brandy or alcohol, because the spirits destroy any mold spores that may happen to rest on the jelly. If such spores are covered with the paraffin they may develop under it. However, the paper wet with spirits could be put on first and the paraffin poured over it. If paraffin is used, have the coating about a fourth of an inch thick. In cooling the paraffin contracts, and if the layer is very thin it will crack and leave a portion of the jelly exposed.

Canned or Bottled Fruit Juices.—Fruit juice is most desirable for drinking or for culinary purposes. Grape juice is particularly good as a drink. It may be canned with or without sugar but, except where the grapes have a large percentage of sugar, as is the case in California, some sugar should be added to the juice in canning. Currant juice may be sterilized and canned without sugar. This juice may be made into jelly at any season of the year. Fruit juices that are designed for use in frozen creams and water ices should be canned with a generous amount of sugar. For grape juice good bottles are to be preferred to fruit cans. If you can get the self-sealing bottles, such as pop or beer comes in, the work of putting up grape juice will be light. If bottles are employed, be very careful to sterilize both bottles and corks.

Grape Juice.—Wash the grapes and pick from the stems. Put the fruit in the preserving kettle and crush slightly. Heat slowly and boil gently for half an hour. Crush the fruit with a wooden spoon. Put a sieve or colander over a large bowl and spread a square of cheese cloth over the sieve. Turn the fruit and juice into the cheese cloth; drain well, then draw the edges of the cheese cloth together and twist hard to press out all the juice possible.

Put the strained juice in a clean preserving kettle and on the fire. When it boils up, draw back and skim. Let it boil up again and skim; then add the sugar and stir until dissolved. Boil five minutes, skimming carefully. Fill hot sterilized jars or bottles. Put the jars or bottles in a moderate oven for ten minutes, in pans of boiling water. Have some boiling juice and pour a little of it into the jars as they are taken from the oven, then seal. Place on boards and set aside out of a cold draft. A good proportion of sugar and juice is 1 gill of sugar (about half a cupful) to a quart of juice.

A report of the Canada experimental farms gives an account of a series of experiments on the best means of sterilizing grape juice. The conclusion, which probably applies to sweet cider as well as to grape juice, was that the natural flavor of grape juice may be preserved intact by raising the temperature of the juice gradually to 170° F., keeping it at this point for ten minutes and then quickly bottling it, taking care to use absolutely air-tight and thoroughly sterilized vessels. These vessels should be taken from a tank or kettle of boiling water, immediately filled, and corked or covered with the least possible delay. The use of antiseptics, such as salicylic acid, is considered unwise. They are unnecessary, and may be injurious to health.

Raspberry, Blackberry, Strawberry, and Currant Juices.—With all these fruits except currants, proceed the same as for grape juice, but adding half a pint of sugar to each quart of juice. Currants will require 1 pint of sugar to a quart of juice.

Cherry, Plum, and Peach Juices.—To preserve the juice of cherries, plums, peaches, and similar fruits, proceed as for jelly; add to each quart of juice half a pint of sugar instead of a quart as for jelly. If it is not desired to have the fruit juice transparent, the pulp of the fruit may be pressed to extract all the liquid.

Fruit Sirups.—The only difference between sirups and juice is that in the sirup there must be at least half as much sugar as fruit juice. These sirups are used for flavoring ice creams and water ices. They also make a delicious drink, when two or three spoonfuls are added to a glass of ice water.

Raspberry Vinegar.—Put 4 quarts of raspberries in a bowl and pour over them 2 quarts of vinegar. Cover and set in a cool place for two days. On the second day strain the vinegar through cheese cloth. Put 4 quarts of fresh raspberries in the bowl and pour over them the vinegar strained from the first raspberries. Put in a cool place for two days, then strain. Put the strained juice in a preserving kettle with 3 quarts of sugar. Heat slowly, and when the vinegar boils skim carefully. Boil twenty minutes, then put in sterilized bottles. About 2 tablespoonfuls of vinegar to a glass of water makes a refreshing drink. Similar vinegars may be made from blackberries and strawberries.

Cane Sirup.—

Sucrose	54.20
Glucose	3.70

For keeping sirup for family use, we recommend the ordinary glass fruit jars. They are less trouble than other vessels, and can be used year after year by renewing the rubbers, and occasionally the tops, and, in the end, they are the cheapest. The farmer who produces a small quantity of cane for sirup-making should provide for keeping it on his table the entire year by properly bottling or canning and sterilizing the required amount. He should find the sirup equally palatable at all seasons, and quite economical. The important thing is to kill all ferments in the sirup and vessel by heat, and thereafter prevent others from gaining entrance. In our experiments in preserving sirup in fruit jars, under the precaution given above, none were in the least fermented at the end of one or two years.—(Dept. Agr. F. B. 118, 122, 203; Louisiana Sta. 2nd Series No. 75.)

FOOD ACCESSORIES.

Beverages, condiments, and other food accessories give flavor to the food or increase its palatability, but have little or no food value in themselves. Under the head of food accessories are classed tea and coffee, condiments, flavorings, etc. Pickles might very properly be classed under the same head since they are used more as a condiment than as a food. They have, however, some food value. Although the food accessories neither build tissue nor yield energy, they make the food more palatable and may be of some aid to digestion by causing a more profuse secretion of the digestive juices and in other ways. They are an element of expense, entering, to a greater or less extent, into the dietaries of all families.—(O. E. S. 52.)

COFFEE SUBSTITUTES.

Coffee substitutes of domestic manufacture have long been known. An infusion of parched corn, or corn coffee, has met with some favor in the household as a drink for invalids, etc. Parched wheat, peas, chicory beans, and corncobs, as well as sweet potatoes, cut into small pieces and dried and parched, have also been used. There are a number of coffee substitutes which generally claim to be made from cereals. In most cases the claim is also made that such beverages are especially wholesome, and in some cases that they have a high food value. The value as food of coffee or any such beverage is evidently due (1) to the material extracted from the coffee (or other substance) by the water used, and (2) to the sugar and milk or cream added to the infusion. As the bulk of the infusion is water, it is obvious that the food value can not be great. The infusion of true coffee has very little nutritive value. It is taken for its taste and the stimulating effect of the caffine in it. Cocoa, when made of milk or milk and water, is quite nutritious.

MINERALS AS FOOD.

Mineral Matter.—The foodstuffs we have thus far considered, the fats, carbohydrates and proteins, while essential to the body, are not sufficient for all of its needs, since only five elements, carbon, hydrogen, oxygen, nitrogen, and sulfur are represented. A diet containing only fat, carbohydrates and protein would be so deficient as to cause starvation even more quickly than if all food were withheld.

The remaining elements, together with sulfur, are often grouped under the head of mineral matter, ash or salts. Mineral matter is therefore a vital consideration in the human dietary. It is frequently overlooked because there is so little definite knowledge of the needs of the body for the elements represented. These elements are as necessary in building and repairing tissue as nitrogen.

While we consider mineral matter as a separate foodstuff, it is not so easy to understand as the fats and the carbohydrates, sugar and starch, or the various proteins, for we cannot see it. It is not always a definite, tangible thing. One salt with which we are all familiar and the only one which we knowingly add to the diet is common table salt, which is made up of the two elements, sodium and chlorin. The presence of other ash constituents of mineral matter we shall have to accept on faith and depend upon the chemist to tell us in which foods the various ones are to be found. That we need knowledge of these important foodstuffs, and should give greater consideration to their abundance in the dietary, a brief mention of some of their functions will show.—(Cornell Reading Course for Farmers' Wives, New Series II, No. 6.)

Phosphorus is essential to the development of all the cells. If the food of the growing child is deficient in phosphorus-containing compounds, growth becomes stunted.

Calcium (lime) is very important in the growth of the bones, and serves many other important uses in the activity of the body. If lime is not present in sufficient amounts in the diet of a growing child, the bones and teeth do not develop properly and normal growth may thus be interfered with. Anything which interferes with the health of the bone is likely to interfere with the production of the red blood corpuscles, for they are produced by the red marrow of the bones. If the number of red corpuscles in the blood falls below par the whole body suffers in consequence, for it means not enough oxygen is carried to the cells.

Iron is so important to proper nutrition that most persons are familiar with it through the advertisements of the numerous iron tonics on the market. The use of these tonics would be greatly diminished by a knowledge of right feeding methods, for food iron is what is needed rather than the iron which is sold in a bottle of tonic. Too little iron in the diet means that the cells in the red marrow of the bone lack one of the things needed in making red blood corpuscles. It is the iron which is built into those little bodies which gives them their power of holding oxygen and thus makes them so useful a part of the blood system. Anaemia may result from many abnormal causes, but it may also be produced by improper feeding.

Some of the elements of mineral matter are essential to the body in carrying out many of its most important functions. During the activities of the body waste products are produced, and if these were allowed to remain in this form they would prove exceedingly injurious. It is the function of some of the salts of calcium, magnesium, potassium, and phosphorus to unite with these harmful compounds and make them harmless. Thus they are gotten rid of. The ability of the heart to beat, of the muscles to contract, of the nerves to carry impressions are all dependent upon the presence of some of the salts. The activity of the intestine depends upon them. One fruitful source of constipation is a lack of knowledge of these facts.

Foods Rich in Salts.

Iron	Phosphorus	Potassium	Calcium
Dried beans	Dried beans	Dried beans	Milk
Dried peas	Dried peas	Dried peas	Dried peas
Whole wheat	Whole wheat	Potatoes	Dried beans
Spinach	Egg yolk	Parsnips	Celery
Raisins	Beef	Cabbage	Cabbage
Prunes	Milk	Turnips	Parsnips
Green beans		Prunes	
Meat			
Eggs			

—(Cornell Reading Course for Farmers' Wives, New Series II, No. 6 and 7.)

Baking Powder.—Although baking powder is not added to food for nutrition, it must be considered under mineral foods. Baking powders are a mixture of sodium bicarbonate and some form of acid salt, together with from one-fifth to one-half of their weight of starch or flour. Baking powders may be classed under four kinds, depending upon the acid salt used, viz: First, cream of tartar baking powders; second, alum baking powders; third, alum-phosphate baking powders; and fourth, phosphate baking powders. So far as their efficiency in bread-making is concerned, they are about of equal value; that is to say they all liberate about the same amount of carbonic acid gas when fresh. It is the liberation of this carbonic acid gas in the dough in the process of baking that causes the bread to rise and to be porous.

When baking powders are used in bread-making, a chemical change takes place, caused by the water used in mixing the dough and the heat in baking the bread resulting in the evolution of carbonic acid gas, and a fixed residue remains in the bread. This fixed residue in the case of cream of tartar baking powder is potassium sodium tartrate, usually called Rochelle salts. In the case of alum baking powders or alum-phosphate baking powders, this residue, if the reaction is complete, is sodium sulphate and alumina hydrate or phosphate. In the case of phosphate baking powders, the residue is calcium and sodium phosphates.

In the case of alum baking powders, or alum-phosphate baking powders, there seems to be a difference of opinion as to whether they are injurious to health or not. It often happens that the reaction is not complete in the process of bread-making. In all such cases, alum is left in the bread. This is known to be an astringent and irritant to the mucous membranes. Even when the reaction in bread-making is complete, the alumina hydrate is undoubtedly soluble to some extent in the juices of the stomach and albuminous substances, thus irritating weak stomachs, and is undoubtedly injurious in such cases. England and France, the two countries which have been most careful in regulating the sale of human foods, virtually prohibit the sale of alum powders. Many eminent disinterested scientists condemn their use in no uncertain language.—(Florida Exp. Sta. Bul. 54; Dept. Agr. F. B. 121, 256; O. E. S. Buls. 185, 227.)

SUGAR AS FOOD.

Extent of the Use of Sugar.—The pleasant flavor of sugar, together with what we now know of its nutritive value, will account for its great popularity as a food. It may almost be said that people eat as much sugar as they can get, and the consumption of sugar in different countries is, in general, proportional to their wealth. The English-speaking people are the largest consumers of sugar. In 1895 England consumed 86 pounds per capita and the United States 64 pounds, although still larger amounts are said to be consumed in sugar-growing districts, largely in the form of ripe cane.

By the term sugar as here used, is meant cane sugar, so called because it was first manufactured from the sugar cane, although it is also found in the juice of a number of plants. Besides cane sugar there are a number of other sugars, as grape sugar, fruit sugar, and milk sugar. There are other sugars besides cane sugar. The one most frequently met with is dextrose, or grape sugar, which is much less sweet than cane sugar and differs from it chemically. It may be seen in yellowish grains in the raisin and is found in small quantities in other fruits.

If cane-sugar is cooked with an acid, such as vinegar or cream of tartar, a part of it is changed to a form of sugar known as glucose. Glucose is much less sweet than cane-sugar and does not crystallize easily. The presence of glucose in a cane-sugar solution retards crystallization, and hence is useful in much of our sugar cookery. It may be purchased.

The corn-syrup on the market is made by cooking starch with an acid. The starch is changed to glucose. Such a syrup is noticeably less sweet than sugar and crystallizes much less readily than a syrup made from either ordinary sugar or maple-sugar. It is also very much cheaper. Maple sugar is one form of so-called cane-sugar. In the manufacture of maple-syrup, acid, present as impurities, produces a small amount of glucose and this aids in preventing crystallization.

All sugars are carbohydrate and are useful to supply energy. They are almost completely digested and very quickly available for energy. The main function of sugar in the blood whether obtained from the digestion of sugar or of starch is believed to be the production of energy. Experiments have shown that sugar prevents fatigue or relieves it. The Maine lumbermen use great quantities of sugar, syrup, and sweet cakes when engaged in severe work. The Canadian lumbermen even add molasses to their fat salt pork. The Swiss guide thinks lump sugar and highly sweetened chocolate an indispensable part of his outfit. Sugar is valuable in cold climates and is used on Polar expeditions. The food value of candy depends on the sugar in it.

Sugar would seem to be especially adapted to children's use, because of their activity. Many authorities think however that it is better to withhold sugar till after the second year and that it should not be added to cereals. It is better furnished in the simple pudding, a lump of sugar, or homemade candy.

Sugar is a useful and valuable food. It must, however, be remembered that it is a concentrated food and therefore should be eaten in moderate quantities. Further, like other concentrated foods, sugar seems best fitted for assimilation by the body when supplied with other materials which dilute it or give it the necessary bulk.

Persons of active habits and good digestion will add sugar to their food almost at pleasure without inconvenience, while those of sedentary life, of delicate digestion, or of a tendency to corpulency would do better to use sugar very moderately. It is generally assumed that 4 or 5 ounces of sugar per day is as much as it is well for the average adult to eat under ordinary conditions.

NUTS.

Nuts are a very concentrated food, even more so than cheese, but when rationally used they are well assimilated and may form a part of a well-balanced diet. Nuts are a very valuable source of protein and fat, these two nutrients being the characteristic constituents of the more common nuts, of which the walnut and cocoanut may be taken as types. In nuts like the chestnut, carbohydrates are a characteristic constituent. For most families it is undoubtedly wiser to use nuts as part of the regular diet than as a condiment or supplement to an otherwise hearty meal.

Vegetarians and others who use nuts in place of meat should not depend upon them as the main food supply, but should supplement them with more bulky foods with a low content of protein and fat. As a whole, nuts may be classed among the staple foods and not simply as food accessories. At usual prices, nuts are reasonable sources of protein and energy. Peanuts supply protein and energy very cheaply, even compared with such staple foods as bread and beans. There are a number of nut foods on the market, but it may be stated that there is little to be gained from the standpoint of food value or economy in their use in place of the ordinary nuts and home-made nut products, especially by healthy persons who are willing to masticate their food thoroughly and to use nuts in reasonable combinations. Nut butters and similar foods give a pleasant variety to the diet, and they are relished by many.

OLIVE OIL.

This is the oil expressed from ripe olives. It is prized for its delicate flavor and high nutritive value. It is used principally as a salad oil in the United States and might be employed more freely. It is frequently adulterated with peanut oil, cottonseed oil, lard oil and some other vegetable oils.

COTTONSEED OIL.

This is used to a large extent as a salad oil, but is frequently sold as olive oil. It has a pleasant flavor and odor and does not become rancid so easily as olive oil.

PEANUT OIL.

Peanut oil has a pleasant, nutty flavor and in Europe is used extensively under its own name. It could well be used as a salad oil to take the place of olive oil.

SUNFLOWER OIL.

Sunflower oil has a mild taste and pleasant odor and is used in Europe for culinary purposes.—(Bur. Chem. Bul. 77.)

CARE OF FOOD.

Introduction.—The woman who presides over a household should consider as one of her most important functions the purchase of food and its storage preliminary to use in the kitchen. Should she be living on a farm she will buy less in amount than the woman who lives in the town or city, but, on the other hand, the storage of food will demand more of her attention. Scientific investigation has also thrown light on many of the processes concerned and the result of such labors should be at the service of the householder. The health and efficiency of the family is the chief object of her care, and it is an end well worth the effort. In the buying, storing, and handling of food it is most important that we realize the causes of what is called the spoiling of food.

Countless numbers of tiny living things called micro-organisms, a word meaning simply small living things, are everywhere found which will grow in the food man has prepared for his own use and cause it to spoil. The bulk of these minute forms of life are harmless, some are useful, like those which ripen milk; and many are harmful, since they cause waste or may be a direct cause of disease.

They may be found in the cleanest room, but they exist in far greater numbers in dirty quarters. Not only do the micro-organisms appropriate our food, but they sometimes leave behind a disagreeable, musty and moldy odor and flavor, the substances called ptomaines, which are sometimes poisonous. The housekeeper's success in preserving food from deterioration depends very largely on her ability to reduce the number of these unbidden guests to the lowest possible limit. Storing and handling of foods are essentially bacteriological questions, so some knowledge of the nature of these microscopic plants is here in order.

Yeasts and Their Utilization.—Not until millions of yeast cells are massed together do they become visible to the eye as in the compressed yeast cake. Yeast plants are practically everywhere and are of many varieties. Even when we are able to utilize the life processes of the yeast plant, its good offices, as we have seen in bread-making, are paid for with a certain amount of food material. Food that is to be protected from yeasts must be kept well below 70° to 90° F.

The appearance of mold on foods is familiar to every housewife; mildew on cloth is a less commonly recognized form of mold. The spores (i. e., the minute reproductive bodies) of the different varieties of mold are everywhere and need only warmth and moisture to enable them to grow. Absolute cleanliness in the storage place is essential. Fresh air, sunshine, and whitewash are important aids. The undue use of water should be avoided, as moisture is one of the chief requisites of growth. A cellar may be kept dry by placing in it dishes of unslaked lime, which takes up the moisture. When the lime crumbles apart, it has become "slaked," will take up no more water, and must be renewed. The growth of most molds is retarded by light, ventilation, and low temperature. From the standpoint of household sanitation bacteria are by far the most important of the three groups of micro-organisms under consideration. They are very widely distributed and found in all food exposed to dust and air, milk being a favorite. We can not get away from them without going into the highest mountains or to the polar regions; but we can protect our food supply from their undue growth. It is of primary importance that bacteria be prevented from getting their start. Hence, only such foods should be bought as are in the freshest and best possible condition. They should be consumed as soon as possible after purchase or subjected to the following conditions: Utensils that come in contact with them must be thoroughly scalded, or better, boiled. The hands and clothing of the worker must be kept clean. Of cooked foods, moist vegetables, cooked fruits, made dishes like meat pies and similar dishes are particularly liable to spoil or sour. The temperature at which food is kept should be reduced, usually as near the freezing point as possible.

Since the water content of food must be above 25 per cent before bacterial life is possible in it, we may preserve food by drying it. This method, often in combination with salting and smoking, is applied to fish, meat, vegetables, and fruit. By exposing food to 150-160° F. of heat for half an hour, almost all varieties of bacteria would be killed. The spores would in certain cases resist this degree of heat. The pasteurization of milk offers an example of a food that is kept from spoiling by this method.

Most varieties of bacteria are killed in a few hours by direct sunshine, but it must be direct. We may often make use of substances that inhibit bacterial growth, such as a very heavy sugar solution, in preserving fruits. Vinegar, spices, salt, and wood smoke have a like effect, and their use is familiar in pickled and spiced vegetables and fruits and in salted and smoked meats.

Ptomaine Poisoning.—In some foods bacteria in the early stages of their action leave no disagreeable or unhealthful effects, so far as yet proved. The gamey taste given meat by hanging comes in part from the bacteria though the changes are chiefly due to the action of ferments normally present. It is not easy to draw the line between the harmless ripening processes and the bacterial changes classed as decay.

The food may become dangerous even before it shows outward signs of decomposition, for the bacteria may give off substances known as ptomaine, some of which are very poisonous. It is not known under what conditions these ptomaine poisons are developed in foods; we know only that they are the result of bacterial action.

Disease Germs and Polluted Water.—The so-called germs of typhoid fever, diphtheria, and tuberculosis are bacteria, and as they may be conveyed by means of water or food this danger is a very real and serious one. Science has shown us that insects, especially flies, may carry bacteria to our food. They should, of course, be excluded from our homes and kept away from our food supplies. Dust, too, may be very dangerous, and should be avoided as far as possible. Another possible source of danger, frequently overlooked, is the presence of pet animals in the kitchen. Rats and mice are disagreeable pests and no one wants to eat food they have touched as they are known to carry disease.

The food brought into the house should be clean and of good quality. Clean shops and markets and sanitary bakeries are a necessity. With cold storage goods it is important that they be used very soon, especially poultry and fish. Poultry, meats, and vegetables should be carefully selected and carefully protected from contamination.

Ice chests and refrigerators are valuable aids in keeping food, but must be carefully attended to, cleaned and scalded, as there are bacteria that grow at low temperature. Ice is not always free from dirt. A cloth folded about the piece of ice tends to protect it from outside heat and catches any dirt frozen in the ice. It should be scalded after each using. All cooked food should be cooled as soon as possible before being placed in the ice box. Butter may be kept from taking up the flavors of other food by keeping it in a tightly covered receptacle. Milk requires more access of air, but in a clean ice box in which no strong-smelling food is kept milk should remain uninjured in flavor for twelve to twenty-four hours. If vegetables or other foods of pronounced odor are kept in glass jars with covers or in covered earthenware receptacles there will be fewer odors to be communicated. Portions of canned food should never be put into the ice box in the tin can. Such food does not of necessity develop a poisonous product, as has sometimes been claimed, but experiments show that ptomaines are particularly liable to develop in such cases. Casting out this somewhat remote possibility, the tinny taste acquired by such keeping is enough to condemn the practice.

Refrigerator ice is often dirty, and may bring in putrefactive or even typhoid bacilli, for most bacteria are not destroyed by freezing. On this account no food should be brought into direct contact with it, nor should it be put into drinking water, unless its purity is above suspicion.

The Keeping of Vegetables, Fruits, and Meats.—The following hints regarding the keeping of different kinds of food may be found useful: Potatoes are kept without difficulty in a cool, dry, and dark place. Sprouts should not be allowed to grow in the spring. Such roots as carrots, parsnips, and turnips remain plump and fresh if placed in earth or sand filled boxes on the cellar floor. Sweet potatoes may be kept until January if cleaned, dried, and packed in chaff so that they will not touch each other. Pumpkins and squash must be thoroughly ripe and mature to keep well. They should be dried from time to time with a cloth and kept, not on the cellar floor, but on a shelf, and well separated from each other. Cabbages are to be placed in barrels, with the roots uppermost. Celery should be neither trimmed nor washed, but packed, heads up, in long, deep boxes, which should then be filled with dry earth.

Tomatoes may be kept until January, if gathered just before frost, wiped dry, and placed on straw-covered racks in the cellar. They should be firm and well-grown specimens, not yet beginning to turn. As they ripen they may be taken out for table use, and any soft or decaying ones must be removed.

Apples, if for use during the autumn, may be stored in barrels. Look them over now and then to remove decaying ones. If they are to be kept till late winter or spring they must be of a variety known to keep well and they must be hand-picked and without blemish or bruise. They should be wiped dry and placed with little crowding on shelves in the cellar. As a further precaution they may be wrapped separately in soft paper. Pears may be kept for a limited time wrapped or packed in sawdust or chaff, which absorbs the moisture which might otherwise favor molding. Oranges and lemons are kept in the same way. Wrapping in soft paper is here essential, as the uncovered skins if bruised offer good feeding ground for mold. Oranges may be kept for a long time in good condition if stored where it is very cold but where freezing is not possible. Lemons and limes are often kept in brine. Cranberries, after removing soft ones, are placed in a crock or firkin and covered with water. A plate or round board placed on top and weighted serves to keep the berries under water. The water should be changed once a month.

In winter large pieces of fresh meat may be purchased and hung in the cellar. Thin pieces, as mutton chops, are sometimes dipped in mutton suet, which keeps the surface from drying and is easily scraped off before cooking. Turkeys, chickens, and other birds should be carefully drawn as soon as killed and without washing hung in the coolest available place. Smoked ham, tongue, beef, and fish are best put in linen bags and hung in the cellar. Salt pork and corned beef should be kept in brine in suitable jars, kegs, or casks, and should be weighted so as to remain well covered. Eggs may be packed for winter use in limewater or in water-glass solution. Many housekeepers have good success in packing them in bran, in oats, or in dry salt, but according to experiments the very best way to preserve them is to use a solution of 1 part water-glass, sodium silicate, to 9 parts of boiled and cooled water. Clean nesting places are necessary to prevent infection in the nest. The eggs should be gathered daily and kept in a dry, cool room or cellar where the sun's rays do not fall directly upon them. Only clean eggs should be used for preservation and these should be placed in the preservative within twenty-four hours after they are laid. They must not be washed as this removes the natural protective covering of the shell.

Eggs laid during April, May, and early June were found to keep better than those laid at any other season. It is recommended, therefore, that only eggs laid at this season be preserved. It was found that water glass when properly made seals the eggs to prevent further infection and when kept at a comparatively low temperature prevents the multiplication of bacteria (decay) within the egg. Water glass can usually be obtained through druggists at from $1 to $1.25 per gallon, a gallon of the water glass being made into 10 gallons of preservative by simply dissolving it in 9 gallons of water which has been boiled and cooled before use. The preserved eggs should be kept in a cellar or room of even temperature which does not go over 60° F.

If care is taken to select clean, sound eggs, and proper precautions are observed in carrying out the details of the method of preservation as above indicated, it is believed that water glass furnishes a cheap, reliable, and easily employed preservative for domestic use, and by its use everyone having a supply of fresh eggs in the spring can make a considerable saving, and at the same time have a larger number of fresh eggs to use in the winter. Eggs should always be washed before breaking.

Storage of Groceries, Cooked Foods and Canned Goods.—Aside from accidental contamination the chief destructive agencies in stored flour and similar materials are fungi and bacteria. Storage in well-lighted, warm and dry rooms is a preventive of the development. The various prepared or self-raising flours are more expensive than the mixture that the housewife can easily make by adding the requisite amount of baking powder to flour and sifting it several times. It is a convenience and a saving of time to keep this mixture on hand, as one sifting provides enough for a month's use in cakes and muffins.

The fact that many of the breakfast cereals can be bought in packages is a great advantage from a sanitary point of view. If bought fresh and well cared for, they will remain in good condition for months. If bought in bulk they should be kept in tight receptacles in a cool, dry place. Crackers may be kept like breakfast cereals, either in the packages, in tin boxes or in jars. Corn meal spoils more readily than flour, and for most families it is best to buy in small quantities. Rice, tapioca, macaroni, and similar dry materials may be kept in covered cans or small crocks in a dry, clean place, as may raisins, Zante currants, evaporated and dried fruits, and similar supplies. Sugar and salt are best kept, the former in tin, the latter in wooden or crockery receptacles. Glass preserve jars are perhaps the best and most convenient containers for small quantities of any food material.

While cooking, newly baked bread should be lightly covered with a clean cloth or paper to prevent mold germs and dust from falling upon it, but should not be tightly wrapped in a thick cloth. When perfectly cold it should be placed in a close receptacle that has been thoroughly scalded and aired. If it is to be kept for more than two or three days in damp, hot weather, the jar or box should be taken out and sunned for a short time now and then, and again scalded and dried.

Cake and cookies should be cooled after baking and kept in tin boxes or in earthenware jars, which should be often scalded and aired. Even if these foods are to be eaten at the next meal it is well to keep in some such receptacle, as it protects from dust. A cake, pudding, or pie put out of a window uncovered to cool or in any other place where it is exposed to dust, and in summer also to flies, is something that no careful housewife would place on her table if she stopped to think how easily the food may be contaminated.

Commercial canned goods may be bought by the dozen in the autumn, as they do not suffer from even a poor storage place, provided it is not so damp that the cans rust through. If dirty or dusty, the cans should always be carefully wiped before they are opened to prevent accidental soiling of the contents. Vegetables and fruits canned at home and homemade jellies, jams, and similar foods should be kept in dry, airy storage places, out of direct light.

Canning may also be made use of daily for temporary preservation of food, especially where ice-chest facilities are not good. When making soup stock a large quantity is made as easily as a small, and the surplus may be poured, while hot, into fruit jars and sealed. Boiled milk, cooked vegetables and mince meat may also be canned, but mince meat will keep a long time in an ordinary receptacle if melted suet be poured over the top. Such canning is only recommended for a few days' keeping, and every precaution should be taken that is familiar in the ordinary canning of fruit or vegetables. All stores should be plainly labeled.

Dishwashing.—The bacteriologist finds no kitchen clean enough and the ordinary methods of washing dishes he is likely to call a smear. Dishes have been tested to determine the number of organisms that remain on them after ordinary washing as compared with a method that requires an application of hot water with the help of soap or, better still, carbonate of soda, a thorough rinsing in hot water, and wiping with a sterilized cloth (that is, one which has been in boiling water since it was used before). By this latter method the dishes were practically sterile while many organisms were left on the dishes that were washed by the ordinary method.

In washing milk utensils it is first necessary to remove with warm water all traces of the milk before scalding water is used. Because of the cream adhering to the sides soap is used also, but the greatest care must be taken to remove by repeated rinsing every trace of soap. The utensils must then be dipped into absolutely boiling water for a moment. It is an important matter to wash the milk bottle in which milk is now commonly delivered to customers before it is opened. It is safe to say that this is seldom done. Personal cleanliness is of course essential in the kitchen, and every good housekeeper endeavors to maintain a high standard in such matters.

Everyone will admit that there is need for exercising great care in coughing and sneezing. Experiment has shown that a fine spray of saliva may be thrown in all directions for a distance of 4 or 5 feet by a violent sneeze or cough and that often the cause of the cough or sneeze is something which can be thus communicated to others. Particularly is this essential wherever food is prepared, exposed, or served.

Use of Paper in the Kitchen.—Paper has many uses in the kitchen. The cook needs a piece of paper on which to drain the fried croquette or fritter and she reaches out for the brown paper that came around the meat or for the grocer's bag. She turns to the same source when she wishes paper for lining a cake pan. A little reflection will show how far from cleanly is this practice. In every kitchen should be found a roll of grocer's paper on its frame. You are sure here of something that has not been handled since it was rolled up by machinery in the factory. Paraffin paper should also be at hand for covering food, for wrapping up sandwiches for school lunches, and for similar purposes.—(F. B. 413, 375.)

ADULTERATION OF FOOD.

Since the middle of the last century the subject of food adulteration has attracted a constantly increasing amount of attention. In the United States very little was done in this line until about 1880. In 1881 the Division of Chemistry began the study of food adulteration, and since then has given a great deal of time to the subject.

Adulterations are carried to such an extent that it may be said truthfully that the adulterant is oftentimes adulterated. Spices are adulterated by adding ground cocoanut shell, lamp black, wheat products, etc., to give bulk, or by extracting the essential oils in part. Meats are preserved in borax and sausages contain a red dye to give an inviting color. Syrups are made up largely of glucose, which costs the manufacturers only a few cents a gallon, and the mixture is sold at a large profit. Jellies and jams often contain glucose, starch paste, gelatine, some preservative, and an aniline dye, to give the color that makes the store goods look so much more inviting than the home made product. Catsups are preserved with benzoate of soda, benzoic acid or some other modern preservative, colored with an aniline dye, and contain pumpkin and starch paste to give body.

Extracts for flavoring in many cases are not made from the material claimed. Some lemon extracts contain no lemon oil whatever. Vanilla substitutes are made from the tonka bean; and there are others that could claim as marked a reputation for the fraud perpetrated.

Milk is often watered or skimmed, or both, and a preservative, generally formaldehyde, is added and sometimes a color. Chemically preserved milk is often fed to the babies, with effects of which we sometimes have our suspicion. Ice creams are adulterated with starch, gelatine, and made of skim milk, served in "cones" preserved with borax.

Oysters are preserved with formaldehyde. Pickles contain copper salts to fix the green color. They sometimes contain a preservative also.

Canned vegetables are soaked goods in a number of cases; preservatives have been found in a large number of cases, and aniline dyes, or other coloring matter. Canned fruits are often colored and a preservative added. Some vegetables and fruits contain acids which attack the tin, forming a poisonous compound.

Distilled vinegar made from wood is colored with burned sugar and sold as cider vinegar. The retailer oftentimes adds water to fill up until the customer is practically paying for so much sour water.

FOOD LAWS.

Three purposes are contemplated in the enactment of food control laws. The protection of public health, the protection of the consumer against fraud and the protection of honest industry. If the adulteration of foods presented a hygienic problem only these laws would be easy to enforce. But the problem presents a commercial side; many interests are intrenched in the business of adulterating and false labeling, so much so that food commerce must be revolutionized before the principles of honest standards and truthful labels will be put into practical effect in the factory.

It is claimed that honest labels discriminate in favor of the genuine product. All products have the right to whatever discrimination the merit system of competition will impose.

Food legislation has claimed much attention abroad but although a Federal pure food bill has been before Congress continuously for over twenty years it was not until June 30, 1906, that such a bill became a law and provisions made for carrying it into effect.

Scope.—The law forbids the introduction into a State or Territory of any article of food or drugs, adulterated in the meaning of the act, from any foreign country, State or Territory, or the District of Columbia, or its shipment to a foreign country. The regulations for carrying out the provisions of the act are to be made by the Secretary of the Treasury, the Secretary of Agriculture, and the Secretary of Commerce and Labor. The examinations of specimens of food and drugs are to be made by the Bureau of Chemistry or under its direction. It is the duty of each district attorney to whom the Secretary of Agriculture shall report any violation of

An Inexpensive Cement Milk House.

Cement Cooling Tank in Cold Storage Room.

this act, or to whom any health or food or drug officer or agent of any State, Territory or District of Columbia shall present satisfactory evidence of such violation, to cause appropriate proceedings to be commenced and prosecuted in the proper courts of the United States, without delay. No dealer can be convicted when he is able to prove a guaranty of conformity with the provisions of this act, signed by the manufacturer or party from whom the goods are purchased, provided they live in the United States.—(Tex. Exp. St. Chem. Bul. 91.)

A food is considered adulterated: First. If any substance has been mixed and packed with it so as to reduce or lower or injuriously affect its quality or strength. Example. Cocoa mixed with starch. Second. If any substance has been substituted wholly or in part for the article. Example. Glucose used in place of sugar in jellies, jams. Third. If any valuable constituent of the article has been wholly or in part abstracted. Example. When milk is skimmed and cream removed. Fourth. If it be mixed, colored, powdered, coated, or stained in a manner whereby damage or inferiority is concealed. Example. Many brands of catsup. Fifth. If it contains any added poisonous or other added deleterious ingredient which may render such article injurious to health. Example. Foods containing preservatives, as meats containing borax; milk containing formaldehyde. Sixth. If it consists in whole or in part of a filthy, decomposed, or putrid animal or vegetable substance, or any portion of an animal unfit for food. Another section deals with imitations, false labels, short weight packages, etc.

The State Pure Food Laws are similar to the Federal Law, but their provisions apply only to the control of material imported into, manufactured in and sold in the State.—(Bu. of Chem. Bul. 104; Wyoming Exp. St. Bul. 56; Kentucky E. S. B. 119; Texas E. S. B. 91; N. Dak. E. S. B. 57, 53; Conn. E. S. Rept. 1902, Part III.)

PRESERVATIVES.

Probably no phase of the Pure Food Laws is of greater importance to both consumer and manufacturer or dealer than that relating to the use of preservatives. The manufacturer finds that by employing them he can use inferior and cheaper produce or even refuse, can make up larger quantities at a time, and can assure the consumer of the keeping qualities of his products even after the package has been opened. He claims that, used in the small quantities necessary for the preservation of the food, they are no more harmful than the salt, vinegar, and wood smoke, which have been in use for so many years. But this has not been proven to be the case. Many of the preservatives used are comparatively new in foods and their effects on the human system when used for a long time even in minute quantities have not been observed and studied. Most of them are poisons if taken in larger quantities.

But some of them have been studied and used in feeding experiments both with animals, and what is of more importance with men. Results in many cases, which will be discussed later, have proven that they are not without injurious effect on the human system. Again what may prove harmless for healthy men may be not only injurious but actually poisonous to those ill, convalescent, or to young children and babies—even in minute quantities. But, what is meant by "small quantities"? There are foods on the market containing many times the amount of preservative actually needed to preserve them and as a Wyoming bulletin truly puts it: "When the greater part of the foods used in this State are shipped in from neighboring States and the foods are necessarily from two to ten days on the road, the subject of preservatives becomes one of vital importance to the people of Wyoming. If we sit down to a dinner and eat canned vegetables, preserved with salicylic acid, meats containing boric acid, catsup with benzoic acid, canned fruit containing salicylic acid, milk containing formaldehyde, bread containing alum, and a number of these containing a goodly sprinkling of poisonous aniline dyes and perhaps some compounds of copper, the amount of preservatives and poisonous material taken into the stomach is not a negligible factor. Chemical preservatives cannot be considered as harmless, and it is now unlawful to use them to preserve food products."

There are firms engaged in the business of manufacturing and selling these preservatives with the statement that they are harmless and that they comply with the food laws. In this way some small manufacturing companies have unknowingly violated the law and others have put on the market preparations containing a preservative when none was used in the factory. A case in point was one in which borax was found in mince-meat. This was traced to raisins so treated before the firm bought them. In another case the formaldehyde found in condensed milk had been used by the producer who delivered the milk to the factory.

These products under various names are sold to farmers and housekeepers at large profits. Some of them and their names are given below. Freezine, Preservaline, Milk Sweet, contain formaline; extract of Salyx is salicylic acid; butter preservative, borax, boric acid and salt; general preservative for fruits and meats, sodium sulphite. Secret preparations for "cold process" preserves are sold to many housekeepers and often when used according to directions for keeping fruit without any heat are used far in excess of that which even the advocates of food preservatives advise.

A weak solution of formaldehyde is used as an embalming fluid by specimen collectors of small animals and also by undertakers.—(Wyoming Sta. B. 56, 62; N. Dak. E. S. B. 63; Bu. Chem. 100.)

INVESTIGATIONS OF PRESERVATIVES.

Doctor H. W. Wiley of the Bureau of Chemistry made a number of investigations of the effects on the human system when chemical preservatives were taken with the food. The first of these was the *Borax Investigation.*

Twelve healthy young men of approved character, not users of alcoholic beverages, some college trained and the majority engaged in scientific work were chosen from volunteers for the experiment. They promised upon honor to observe all rules made for them and at the end certified upon honor that they had done so. The fare was varied and ample. It consisted of the best quality of meats, poultry, fish, butter, milk, eggs, vegetables, fruits, etc. The time varied from 30 to 70 days to study the effect of continued use. The investigation as a whole lasted from Dec. 16, 1902, to June 29, 1903. There were the usual three periods to each experiment. A fore-period to determine the exact condition of each member, the regulation of amount of food needed and during this no preservative was taken; the middle or preservative period; and the after period. At first small quantities such as would be present in the meats consumed were used, and later increased to find the amount that would be tolerated by the system. This borax or boric acid was first mixed with the butter but later taken in capsules. The rations of each member were weighed, the members were weighed, the blood was examined, temperatures determined, excreta weighed and analyzed, and the mental attitude of the men considered also. As the experiments extended over many months the men became used to the fact that they were taking a preservative.

When boric acid, or its equivalent in borax, is taken into the food in small quantities, not exceeding half a gram (7½ grains) a day, no notable effects are immediately produced. The medical symptoms of the cases in long-continued exhibitions of small doses or in large doses, extending over a shorter period, show in many instances a manifest tendency to *diminish the appetite* and to produce a *feeling of fullness* and *uneasiness in the stomach,* which in some cases *results in nausea,* with a very general tendency to produce a *sense of fullness in the head,* which is *often* manifested as a dull and *persistent headache.* There appear in some instances *sharp and well-located pains* which, however, *are not persistent.* Although the *depression in the weight* of the body and some of the other symptoms produced persist in the after periods, there is a uniform tendency manifested after the withdrawal of the preservative toward the removal of the unpleasant sensations in the stomach and head above mentioned.

The administration of boric acid to the amount of 4 or 5 grams per day, or borax equivalent thereto, continued for some time results in most cases in *loss of appetite and inability to perform work of any kind.* In many cases the person becomes ill and unfit for duty. Borax and boric acid are recognized as valuable remedies in medicine, and there are certain diseases in which these remedies are regularly prescribed, both for internal and external use. The fact that any remedy is useful in disease does not appear to logically warrant its use at any other time.

It appears, therefore, that both boric acid and borax, when continuously administered in small doses for a long period, or when given in large quantities for a short period, create disturbances of appetite, of digestion and of health.—(Bur. Chem. Bul. 84, Pt. I, Cir. 15.)

SALICYLIC ACID AND SALICYLATES.

There has been a general concensus of opinion among scientific men, including the medical profession, that salicylic acid and its compounds are very harmful substances, and the prejudice against this particular form of preservative is perhaps greater than against any other material used for preserving foods. This is due perhaps to the fact that it has in the past been so generally used as an antiseptic. Its being regarded as the most injurious of all, is perhaps to a certain extent undeserved. Like other ordinary preservatives, it is not one which can be classed as a poison in the usual sense of the word. When used as a medicine in many cases of derangement of health it is often highly beneficial when properly prescribed by a competent physician. It is, when used in the food, at first an apparent stimulant, increasing the solubility and absorption of the common food elements from the alimentary canal. It soon, however, loses its stimulating properties and becomes a depressant, tending to break down the tissues of the body more rapidly than they are built up. It disturbs the metabolic processes, in most cases producing conditions which are not normal and which apparently are not beneficial. It has a tendency to diminish the weight of the body and to produce a feeling of discomfort and *malaise* which, while not marked, is distinctly indicative of injury. In some cases these symptoms of *malaise* approach illness. When added to foods even in small quantities, exerts a depressing and harmful influence upon the digestive and health and the general metabolic activities of the body. Further, there appears to be no necessity for its use, as food can be preserved in unobjectionable ways without its aid.—(Bur. Chem. Bul. 84, Pt. II.)

SULPHUROUS ACID AND SULPHITES.

The use of these is more general than that of borax or salicylic acid. In the preparation of foods fumes of sulphur are often applied either to the foods or to the containers. As sulphurous acid in some forms is almost universally employed in the manufacture of wines, molasses, and sirups, and in the preparation of desiccated fruits, it is evident that the prohibition of its use would necessitate a radical change in methods of manufacture.

When sulphurous acid is used as a preservative for food products after the manufacture has been completed, it is usually employed in the form of bisulphite of lime or a preparation somewhat similar. The use of sulphurous acid and sulphites never adds anything to the flavor or quality of a food, but renders it both less palatable and less healthful. Every fact which has been brought out, therefore, in the investigation tends to accentuate the justness of the conclusion, namely, that the use of sulphurous acid in foods should be suppressed.

These data clearly show that the administration of sulphites and of sulphurous acid in a free state in the quantities employed produces harmful effects. A tendency is manifested in practically every case to produce headache and digestive disturbances. In many cases uneasy sensations and even pain were developed in the stomach and intestines, and there were complaints of heartburn. There were also in some cases attacks of dizziness and palpitation of the heart. In a few cases nausea was developed to the extent of vomiting. It can be safely said from the evidence adduced that the administration of sodium sulphite and sulphurous acid, as above indicated, produces a marked influence of an unfavorable character on metabolism. As a result of this action, an assimilation of food materials containing organic phosphorus is retarded. The sulphur balance sheets show what an immense burden has been added to the already overworked kidneys, which are called upon in this case to remove nearly all, if not quite all, of the added sulphur from the body, previously converted, in great part, to sulphuric acid. It is not positively that of a decidedly harmful nature. Another effect which the administration of the sulphur produced, and one of a more serious character still, is found in the impoverishment of the blood in respect of the number of red and white corpuscles therein. —(Bur. Chem. Circ. 37.)

Benzoic acid and benzoates have recently been elaborately considered by Dr. Wiley, whose judgment has been disputed by private concerns which use these substances on a large scale in their products. These disputes are yet pending.

FORMALDEHYDE.

The formaldehyde in the quantities administered did not produce any marked symptoms before ten days; then headache and pain in the stomach and intestines became general, in many cases producing cramps, and in a few cases attended by nausea and vomiting. A burning sensation in the throat was reported in the majority of cases. In four cases well marked itching rash appeared on the chest and thighs, causing great discomfort, slight symptoms of this nature being reported in a fifth case. There is increased absorption of the proteid elements of the food, and also of the sulphur and phosphoric acid, accompanied in the first two instances by a decrease in the metabolized elements excreted, and in the last instance, namely, phosphoric acid, by a pronounced increase in metabolism.

The final conclusion, therefore, is that the addition of formaldehyde to foods tends to derange metabolism, disturb the normal functions, and produce irritation and undue stimulation of the secretory activities, and therefore it is never justifiable.—(Bur. Chem. Circ. 42.)

SACCHARIN.

Saccharin is an artificial sweetener, which has about five hundred times the sweetening power of sugar. Saccharin has antiseptic properties. It has no food value, such as is usually associated with sweetness, and its elimination throws work on the kidneys. It prevents decay and retards digestion to that extent. The use of saccharin, or any other artificial sweetener in any food product should be forbidden by law.—(Tex. E. S. B. 91; N. Dak. E. S. B. 57.)

EFFECT OF PURE FOOD LAWS.

In North Dakota, where they have had a pure food law since 1901, the effect of its enforcement upon the quality of goods imported into and sold in a state may be studied. Under the direction of E. F. Ladd, chemist of the Experiment Station, over 1,600 samples have been examined. There has been a marked decrease in the percent of adulteration in nearly every line.

Today short weight and sloppy goods are largely a thing of the past. The agitation in favor of a net weight proposition has done much to improve the quality as well as the actual amount of food material contained in the cans themselves. The principal intentional violators of the law at the present time are apparently the catalog houses which still continue to ship goods into the state direct to the consumer and therefore cannot be reached by this department. The enactment of a national law will, very materially reduce the sale of the class of goods now found to be in violation of our food law.—(N. D. Ex. St. Bul. 53, 57, 63, 69.)

COLORING MATTER.

Artificial color is added to many of our food products. Sometimes these coloring substances are harmless vegetable substances, but oftener aniline or coal-tar dyes or metallic salts are used. They are used in jellies and jams, in catsup, in pickles, in butter, in milk, in canned vegetables, and in meats—usually the chopped meats such as Hamburg steak and sausage, in soda fountain syrups and many so-called temperance drinks.

In addition to any influence on digestion and health which the coal-tar colors may have, a certain amount of arsenic is added to them by some methods of preparation. In some colors, however, prepared with a special view to use in foods, arsenic is practically or entirely absent. The amount of coloring matter necessary to give a food the desired tint is very small, and the danger to health resulting from its use should not be exaggerated. The question of fraud, however, remains, and the use of colors enables the manufacturer to give inferior products the appearance of high-priced goods, or they may be used merely to produce an appearance more attractive to the eye and in accordance with popular taste, even though the best materials are employed.

Certain foods have associated with them certain colors, and we often judge the condition of the food by the color it has. Bolted flour, granulated sugar and starch are white. Vegetables have their characteristic colors. Fruits present different shades of color by means of which the ripeness of the respective fruit is judged. The richness of milk is sometimes judged by the yellow tinge from the globules of butter fat it contains. Fresh meats have a color distinct from spoiled meats.

In the market foods are selected largely by their color. When this not pleasing the manufacturer often supplies the color, or changes it to the color of a better article. Canned vegetables have their color fixed by a mordant, as copper salts or alum, and instead of the dull color, a pleasing green tint is given the goods.

Aniline or coal tar dyes are now extensively employed in coloring canned goods, candies, meats, catsups, most preserves and jellies, and many so-called temperance drinks, such as sodas and pops. Many of the coal tar dyes are known to be poisonous.—(Bur. Chem. 100; Wyoming St. 33.)

SOME OTHER INFORMATION FOR CONSUMERS.

Do not buy catsup from a keg or jug, or jelly from a bucket which stands open in the grocery store day after day. Examine the label on foods. Insist that your grocers guarantee the quality and purity of everything they sell you for food and drink. The grocer should know his business as well as the doctor, druggist or attorney should know his. Do not eat food which is guaranteed to keep for any length of time in any climate. Such an embalmed mixture has no business in the human stomach. Do not, under any circumstances, buy a bottle or jar or package of food in the original package which is not labeled with the name and address of the manufacturer who puts it up. The information which the law commands shall be made known to the consumer, is often printed in small type or placed where it is least liable to be read, or put in terms with which the general public are not familiar.

The following paragraphs explain some of these terms and point out where to look for the labels and what they mean. The labels reproduced in the illustrations were taken from articles of food on sale in Kentucky.

EXPLANATIONS OF TERMS USED IN LABELS.

Benzoate of Soda, **Benzoic Acid,** **Boric Acid,** **Salicylic Acid,** **Formaldehyde,** **Freezine,** **Preservaline,** **Sulphites,** **Saccharin,**	**Are terms used in labels indicating the presence of antiseptics.**
Corn Syrup, **Grape Sugar,**	**Are terms indicating the use of glucose.**
Distilled Vinegar, **Family Vinegar,** **Grain Vinegar,** **Colored Vinegar,**	**Indicate that the vinegar is not Apple or Cider Vinegar.**
Acquic Acid, **Aluminum Sulphate,** **Sulphate of Aluminum,**	**Are terms used indicating the presence of alum, in Baking Powder.**

Artificial color usually conceals some adulteration or inferiority. The phrases non injurious coloring and preservative used, harmless coloring used, usually denote some antiseptic or aniline dye whose effect on health is questionable.—(Ky. Sta. Bul. 119.)

Pure glucose is a good food, but it has not the food or market value of cane syrup, sugar syrup or honey. It is a fraud all along the line to sell it under these names. Manufacturers of high grade catsup are leaving the coal tar dyes out of it, which means that uncolored catsup must be made from whole ripe tomatoes, and without starch, in order to present a good color. Antiseptics are used in smaller quantities than formerly. All catsups are labeled now to show their presence.—(Ky. Sta. Bul. 119.)

HOUSEHOLD TESTS.

Coffee.—The difference between the genuine ground coffee and the adulterated article can often be detected by simple inspection with the naked eye, or, better, with a magnifying glass, or a portion of it may be placed in a small bottle half full of water and shaken. The bottle is then placed on the table for a moment. Pure coffee contains a large amount of oil, by reason of which the greater portion of the sample will float. All coffee substitutes and some particles of coffee sink to the bottom of the liquid. A fair idea of the purity of the sample can often be determined by the proportion of the sample which floats or sinks.

Chicory contains a substance which dissolves in water, imparting a brownish-red color. When the suspected sample, therefore, is dropped into a glass of water, the grains of chicory which it contains may be seen slowly sinking to the bottom, leaving a train of a dark brown colored liquid behind them. This test appears to lead to more errors in the hands of inexperienced operators than any other test here given. Wrong conclusions may be avoided by working first with known samples of coffee and chicory as suggested above.

Many coffee substitutes are now sold as such and are advertised as more wholesome than coffee. A few of them contain considerable coffee. This may be determined by shaking a teaspoonful in a bottle half full of water, as described above. The bottle must be thoroughly shaken so as to wet every particle of the sample. Very few particles of coffee substitutes will float.

Butter.—The spoon test has been suggested as a household test, and is commonly used by analytical chemists for distinguishing fresh butter from renovated butter and oleomargarine. A lump of butter two or three times the size of a pea is placed in a large spoon and held above the chimney of an ordinary kerosene lamp or gas burner. If the sample in question be fresh it will boil quietly, with the evolution of many small bubbles throughout and large amount of foam. Oleomargarine and process butter, renovated butter, on the other hand, sputter and crackle, making a noise similar to that heard when a green stick is placed in a fire. If a small portion of the sample be placed in a small bottle and set in a vessel of water sufficiently warm to melt the butter, and kept melted from half an hour to an hour, the fat will be turbid, unless it is genuine fresh butter. If genuine the fat will be clear.

Vanilla.—Vanilla extract may often be judged with a fair degree of accuracy by means of the odor alone. Artificial extracts made by dissolving artificial vanillin in alcohol contain no color of themselves, and to supply it caramel is commonly employed. Caramel may be detected in artificial extracts by shaking and observing the color of the resulting foam after a moment's standing. The foam of pure extracts is colorless. If caramel is present a color persists at the points of contact between the bubbles until the last bubble has disappeared. The test with lemon extract is a solution of lemon oil in strong alcohol. To test a sample place a teaspoonful in a glass and add three or four spoonfuls of water. The result is at first a marked turbidity and later the separation of the oil of lemon on the top of the water. If the sample remains perfectly clear after the addition of water, or if a marked turbidity is not produced, it is a low-grade product and contains very little, if any, oil of lemon.

In Bulletin 100 of the Bureau of Chemistry a number of simple chemical tests for formaldehyde, salicylic acid, copper, dyes and glucose and other adulterants are given. Also there are tests for milk, bleached flour, starch pastes and spices. A few chemicals and a glass funnel are about all that is needed to carry out these tests.—(Bur. Chem. Bul. 100.)

RATIONAL FEEDING OF MAN.

The farmer's wife of all housekeepers should have the easiest time in planning plain but wholesome meals, for she lives in the midst of a wealth of the most desirable foods. Milk and cream, butter, eggs, good vegetables and some fruits are or should be always at her command. It is very poor economy for the persons living on a farm to sell eggs and milk and use the money for buying meat. It is cheaper, and better for the family welfare, to keep a generous quantity of the eggs and milk for home consumption, and if necessary let them take the place of much of the meat now used in such large amounts.

Dietaries and Dietary Standards.—The information gained from a study of the composition and nutritive value of foods may be turned to practical account by using it in planning diets for different individuals or classes of individuals or in estimating the true nutritive value of the food actually consumed by families or individuals. By comparing the results of many such investigations with the results of accurate physiological experimenting it is possible to learn about how much of each of the nutriments of common foods is needed by persons of different occupations and habits of life, and from this to compute standards representing the average requirements for food of such persons.

Methods of Making Dietary Studies.—During the last twenty years much of this practical application of the chemistry of food has been made in the study of actual dietaries. Much work of this kind has been done in England, Germany, Italy, Russia, Sweden, and elsewhere in Europe, and in Japan and other Oriental countries. Within the past dozen years extensive studies have been made in the United States. The simplest way of making such inquiries is to find out what kinds and quantities of food are used during a given period in the household, to estimate the amount of various nutrients which the different materials contain by means of figures given for the average composition of the various articles in tables, like Table I, and then to calculate the cost and amount of nutrients for each person. There are, however, several chances for error in such a method. In the more careful dietary studies, the composition of the food is determined by analyzing samples of materials actually used, and this method assumes that all the food is really consumed, whereas it is very plain that frequently no small portion is wasted in the kitchen, and the amounts of nutrients in the waste are computed by analyzing samples of it.

In preparing the results of dietary studies so that different studies may be compared, another difficulty appears. In a family consisting of father, mother, and two children of different ages the amount of food taken by each is by no means the same, and it would be quite incorrect to divide the whole amounts consumed by four and call the result the amount used per person. It is customary to reduce the food requirements to the standard of one man at moderate work.

Relative Values for Food Requirements of Persons of Different Age and Occupation as Compared with a Man in Full Vigor at Moderate Work.

Man, period of full vigor:		**Boy:**	
At moderate work	**100**	**15 to 16 years old**	**90**
At hard work.	**120**	**13 to 14 years old**	**80**
Sedentary occupation	**80**	**12 years old**	**70**
Woman, period of full vigor:		**10 to 11 years old**	**60**
At moderate work	**80**	**Girl:**	
At hard work	**100**	**15 to 16 years old**	**80**
Sedentary occupation	**70**	**13 to 14 years old**	**70**
Man or woman:		**10 to 12 years old.**	**60**
Old age	**90**	**Child:**	
Extreme old age	**70-80**	**6 to 9 years old**	**50**
		2 to 5 years old	**40**
		Child under 2 years old	**30**

These factors are based in part upon experimental data and in part upon arbitrary assumptions. In making dietary studies in this country blanks are usually prepared to be filled out with statistics of the amounts, kinds, cost, and estimated nutrients of the food purchased, wasted, and actually consumed, and information concerning the number, sex, age, and occupation of the persons for whom the food is provided. Further data concerning the health, nationality, income, and general conditions of the individuals of families have been collected in considerable detail in late studies in the United States.

AMERICAN AND EUROPEAN DIETARY STANDARDS.

Many interesting things come to light on comparing the dietaries of persons with different occupations and incomes and performing different amounts of muscular work. A comparison of the dietaries of the inhabitants of different countries is also interesting. Such comparisons are made in the following table, which includes as well the commonly accepted dietary standards. The figures show the quantities of both total and available nutrients. The fuel value represents the actual amount of available energy, and may be computed from either the total or the digestible nutrients by use of appropriate factors.*

The dietary standards given in the tables are based upon the results of observation and experiment, but are general estimates and not guides to be blindly followed. They are subject to revision in the light of further experimental evidence. The amounts of energy provided in the American standards are somewhat larger than in the European standards (Voit's). This corresponds to the observed fact that people in this country, more especially the working people, are as a rule better fed and do more work than those of corresponding classes in Europe. The quantities of protein in Europe are larger in proportion to the fuel ingredients—that is, the nutritive ratio is narrower—than is found in the average American diet. In this respect the American standards agree more nearly with the diet of well-to-do people in Europe. It is believed that the larger amount of protein represents rather more nearly a physiological ration than do the proportions as found in the majority of actual dietaries.

The American, as a rule, uses more food than the European of the same class. The character of the food is, however, quite different. The poor peasants of Russia and northern Germany live chiefly upon rye bread, potatoes, and some sort of fat. In Italy maize, chestnuts, and acorn meal form an important item in the diet of a considerable portion of the poorer population. The use of meat among the working population of most European and Asiatic countries is very much less general than in America, because its cost is prohibitive.

TABLE IV.—*Food Consumption of Persons in Different Circumstances, and Proposed Dietary Standards (Quantities Per Man Per Day).*

	Number of studies included in averages	Actually eaten.			Digestible.			Fuel value.	Nutritive ratio.
		Protein.	Fat.	Carbohydrates.	Protein.	Fat.	Carbohydrates.		
PERSONS WITH ACTIVE WORK.		*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Calories.*	*1;*
Rowing clubs in New England....	7	155	177	440	143	168	427	3,955	5.6
Bicyclists in New York............	3	186	186	651	171	177	631	5,005	6
Football teams in Connecticut and California........................	2	226	354	634	208	336	615	6,590	6.6
Prussian machinists................	1	139	113	677	128	107	657	4,270	7
Swedish mechanics................	5	189	110	714	174	104	693	4,590	5.3
PERSONS WITH ORDINARY WORK.									
Farmers' families in eastern United States............................	10	97	130	467	89	124	453	3,415	8.2
Mechanics' families in United States............................	14	103	150	402	95	143	390	3,355	7.5

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* These factors are as follows: For each gram of total nutrients, protein 4.0, fat 8.9, and carbohydrates 4.0 calories. For each gram of digestible nutrients, protein 4.4, fat 9.4, and carbohydrates 4.1 calories.

TABLE IV.—*Food Consumption of Persons in Different Circumstances, and Proposed Dietary Standards.*—Continued.

	Number of studies included in averages.	Actually eaten.			Digestible.			Fuel value.	Nutritive ratio.
		Protein.	Fat.	Carbohydrates.	Protein.	Fat.	Carbohydrates.		
PERSONS WITH ORDINARY WORK continued.									
		Gms.	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Gms.*	*Calories.*	1:
Laborers' families in large cities of United States:	12	101	116	344	93	110	334	2,810	6.3
Laborers' families in United States (more comfortable circumstances)	2	120	147	534	110	140	518	3,925	7.6
Russian peasants	......	129	33	589	119	31	571	3,165	5.4
Swedish mechanics	6	134	79	523	123	75	507	3,330	5.5
PROFESSIONAL MEN									
Lawyers, teachers, etc., in United States	14	104	125	423	96	119	410	3,220	7.1
College clubs in United States	15	107	148	459	98	141	445	3,580	7.8
German physicians	2	131	95	327	121	90	317	2.680	4.3
Japanese professor	1	123	21	416	113	19	403	2.345	4
MEN WITH LITTLE OR NO EXERCISE									
Men (American) in respiration calorimeter	11	112	80	305	103	76	296	2,380	4.5
Men (German) in respiration apparatus	5	127	80	302	117	76	293	2,430	4
PERSONS IN DESTITUTE CIRCUMSTANCES									
Poor families in New York City	11	93	95	407	86	90	395	2,845	6.9
Laborers' families in Pittsburg, Pa.	2	80	95	308	74	90	299	2,400	6.8
German laborer's family	1	52	32	287	48	30	278	1,640	7.2
Italian mechanics	5	76	38	396	70	36	384	2.225	6.6
MISCELLANEOUS									
Negro families in Alabama and Virginia	39	86	145	440	79	138	427	3.395	9.3
Italian families in Chicago	4	103	111	391	95	105	379	2,965	6.5
French canadians in Chicago	5	118	158	345	109	150	335	3,260	6.2
Bohemian families in Chicago	8	115	101	360	106	96	349	2,800	5.3
Inhabitants Java village, Columbian Exposition 1893	1	66	19	254	61	18	246	1,450	4.7
Russian Jews in Chicago	10	137	103	418	126	98	405	3,135	5
Mexican families in New Mexico	4	94	71	613	86	67	595	3,460	8.7
Chinese dentist in California	1	115	113	289	106	107	280	2,620	4.9
Chinese laundryman in California	1	135	76	566	124	72	549	3 480	5.7
Chinese farm laborer in California	1	144	95	640	132	90	621	3,980	6.2
United States Army ration, peace	......	120	161	454	110	153	440	3,730	7.1
German army ration, peace	......	114	39	480	105	37	466	2 725	5.2
DIETARY STANDARDS									
Man at hard work (Voit)	......	145	100	450	133	95	437	3.270	4.9
Man at moderate work (Voit)	......	118	56	500	109	53	485	2.965	5.5
Man with very hard muscular work (Atwater)	......	175	(*a*)	(*a*)	161	(*a*)	(*a*)	5,500	7.2
Man with hard muscular work (Atwater)	......	150	(*a*)	(*a*)	138	(*a*)	(*a*)	4,150	6.2
Man with moderately active muscular work (Atwater)	......	125	(*a*)	(*a*)	115	(*a*)	(*a*)	3,400	6 2
Men with light to moderate muscular work (Atwater)	......	112	(*a*)	(*a*)	103	(*a*)	(*a*)	3,050	6.1
Man at "sedentary" or woman with moderately active work (Atwater)	......	100	(*a*)	(*a*)	92	(*a*)	(*a*)	2,700	6.1
Woman at light to moderate muscular work, or man without muscular exercise (Atwater)	......	90	(*a*)	(*a*)	83	(*a*)	(*a*)	2,450	6.1

[a] Fats and carbohydrates in sufficient amounts to furnish, together with protein, the indicated amount of energy.

Among the more scantily nourished peoples of the globe are the poor of India and China. They live largely on rice and other cereals and vegetables, with more or less of pulse and other legumes, and often on quantities which to the ordinary American would seem little more than a starvation diet.

Although there may be occasional wide variations between two individuals of a given class in respect to the total amounts of food eaten, yet, on the whole, through extended periods, there are not unusually large variations in amounts of protein or energy in the food consumed by different individuals of the same class; that is, under similar conditions as regards work or rest.

The study of the ordinary diets of the laboring classes in all countries seems to show that whenever possible a diet is secured which will yield something over 3,000 calories of energy and over 100 grams of proteids per man per diem.

The average requirements of a normal individual are affected by a number of factors, of which the most important are sex, age, size of the body, and the amount of muscular work performed.

Such facts are often disregarded especially the average size of the individuals. For instance, the results of 14 dietary studies with American professional and business men showed that they consumed a diet which supplied 104 grams protein and 3,220 calories of available energy, and with Japanese of similar employment, as shown by 13 studies, 87 grams protein and 2,190 calories of energy. The Americans weighed on an average 150 pounds and the Japanese 105. Considering this diet on the basis of 150 pounds body weight the food eaten would supply 121 grams of protein and 3,130 calories of energy.

Everyone recognizes the fact that hard work means a hearty appetite. Maine lumbermen, while engaged in chopping and yarding, ate food supplying 221 grams protein and 8,140 calories per day. When drawing logs they ate 179 grams protein and utilized 6,835 calories of energy per day, amounts which are still large as compared with the food of men at less active employment. These men were engaged in very severe out-of-door work in a very cold climate, and the amount of food which they ate is very much greater than is eaten by men of similar size on New England farms or in New England factories, who have been found to eat on an average about 100 grams protein and to utilize about 3,425 calories of energy.

It has long been known to physiologists that nitrogen-free nutrients are the chief source of the energy expended in muscular work under usual conditions. The lumbermen showed a decided partiality for foods rich in carbohydrates and fat, and the amount of pastry, sirup, sugar, baked beans, and similar materials eaten was unusually large and accounted for the high energy value. The amount of protein supplied by the diet was also high, partly, perhaps, because with the available foods and the previously acquired food habits, it would have been difficult to secure a sufficient amount of nitrogen-free material without a correspondingly large amount of protein.

The quantity of protein actually required by the body is a very important matter, and a question which is as yet by no means solved. Dietary standards should be in reasonable harmony with physiological demands, and it seems probable that such is the case with those which have been most generally used. That this is true of energy can be shown by the experiments which have been made with the respiration calorimeter in connection with the nutrition investigations of the Office of Experiment Stations.

MINERAL MATTER REQUIRED IN THE DIET.

To be most useful, dietary standards should take into account the amount of ash constituents required by the body, for it is well known that mineral matters of different sorts are essential for use in forming bones and other body tissues for the repair of the body and for other purposes. Many general statements are met with regarding the great importance of mineral matter, and many theories of nutrition have been based to a large extent on mineral constituents. Experimental investigations, particularly physiological studies along these lines, are not very numerous. A recent estimate of the mineral matter required per man per day calls for the following amounts:

Estimated Amount of Mineral Matter Required Per Man Per Day.

	GRAMS.		GRAMS.
Phosphoric acid (P_2O_5)	**3-4**	**Calcium oxid**	**0.7 -1.0**
Sulphuric acid (SO_3)	**2-3.5**	**Magnesium oxid**	**0.3 -0.5**
Potassium oxid	**2-3**	**Iron**	**0.006-0.012**
Sodium oxid	**4-6**	**Chlorin**	**6 -8**

Silica, iodin, fluorin, are required in smaller amounts. With ordinary mixed diet the needs of the body for mineral matter are usually supplied.

Under the Preparation of Food a table is given showing what minerals are furnished by common foods. As a rule the American diet is sufficient for all needs except perhaps in some cases of extreme poverty or ignorance and bad management.

A special phase of the question which has recently received much attention is that of underfeeding among the children in the public schools. There seems little doubt that many children in the congested sections of American cities are decidedly undernourished, though this condition seems less widespread than in some European cities. Wherever it exists this underfeeding is an important factor in the arrested physical and mental development and also in the tuberculosis and other diseases which are so prevalent in such congested centers. It is not only that many parents can not provide sufficient food for their children, but also that they frequently provide the wrong food, or give the children pennies with which to buy their own lunch, with the natural result that they are spent for candy, chewing gum, or questionable push-cart goods.

To meet this difficulty school lunches are provided in districts where they are needed in some cities in this country, and much more generally in Europe. Sometimes the food is furnished by the municipal authorities, sometimes by private charitable agencies working through the school organization. In some cases it is served free to all, in others sold at a trifling sum to those who can afford to purchase it. In this way each child is sure of at least one nutritious and suitable meal a day. Where this has been tried improvement not only in the physical but also in the mental condition of the pupils seems invariably to follow, and most school officials think with experience the matter can be so managed that it brings no danger of pauperization. In the case of school lunches prepared in connection with domestic science courses the children may at the same time be given important object lessons in the proper cooking and serving of food.

KINDS OF FOOD EATEN IN AMERICAN HOMES.

Owing to great range in climate and agricultural conditions, the United States yields food products in great variety, as well as in great abundance. Methods of transporting, storing, and distributing food products have kept pace with improved methods of cultivation, and perhaps at no time and in no country has there been greater variety of products of the farm, field, ranch, and garden from which to select than in the United States to-day.

Data have been summarized which show the proportionate amounts of different foods which make up the diet of the average American home, and the relative proportion of the total nutrients and energy which the principal foods and food groups supply. A summary of such data based on the results of about 400 studies is presented in the table which follows:

Proportion of Nutrients Furnished by Different Food Materials in the Average American Dietary.

Food Materials.	Total food material.	Protein.	Fat.	Carbohydrates.
ANIMAL FOODS.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Beef and veal	7.2	16.7	13.2	....
Lamb and mutton	.9	2.1	2.6	....
Pork, including lard	7.2	9.3	42.1	....
Poultry	.7	1.6	.9	....
Total meats	16.0	29.7	58.8	....
Fish	1.8	3.5	1.0	....
Eggs	2.1	4.1	2.9	....
Butter	1.6	.3	16.6	....
Cheese	.3	1.0	1.1	....
Milk and cream	16.5	8.7	8.0	3.6
Total dairy products	18.4	10.0	25.7	3.6
Unclassified animal foods	.2	.2	.2	.3
Total animal foods	33.5	47.5	88.6	3.9

Proportion of Nutrients Furnished by Different Food Materials in the Average American Dietary.—(Continued.)

Food Materials.	Total food material.	Protein.	Fat.	Carbohydrates.
VEGETABLE FOODS.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Wheat flour, patent	12.2	19.4	1.5	25.6
Wheat flour, entire	.1	.1	....	.2
Wheat flour, graham	.1	.2	....	.2
Wheat preparations	.3	.5	.1	1.0
Wheat bread, patent	5.8	8.1	1.6	12.4
Wheat bread, entire	....	....	....	.1
Wheat bread, graham	.1	.1	....	.2
Crackers	.3	.5	.5	1.0
Sweet cakes, etc	.6	.8	.9	1.4
Corn meal and flour	8.7	10.1	3.8	13.7
Corn preparations	.2	.2	.1	.4
Oatmeal and preparations	.5	1.0	.5	1.1
Rice	.3	.3	....	.9
Rye	1.3	1.6	.1	3.1
Barley and buckwheat	.1	.1	....	.5
Total cereals	30.6	43.0	9.1	61.8
Sugar, molasses, etc	5.4	....	....	17.5
Starch (prepared)	....	....	....	.1
Dried legumes	1.0	2.9	.2	1.7
Fresh legumes	.6	.4	....	.3
Tubers and yams	12.5	3.8	.3	8.3
Other vegetables	6.2	1.6	.5	1.7
Total vegetables	20.3	8.7	1.0	12.0
Fresh fruits	3.8	.3	.3	2.5
Dried fruits	.6	.2	.1	1.2
Total fruits	4.4	.5	.4	3.7
Nuts	....	....	.1	....
Unclassified vegetable foods	.5	.1	.2	.6
Total vegetable foods	61.2	52.3	10.8	95.7
Miscellaneous food materials	.3	.2	.6	.4
Total food materials	100.0	100.0	100.0	100.0

As will be seen, the number of foods which may be called staples and which make up the bulk of the diet is comparatively small, including such articles as wheat flour, meat, milk, butter, dairy products, and vegetables.

It will be seen further that animal and vegetable foods are about equal in rank as sources of protein, some 48 per cent. of the total being supplied by animal foods and 52 per cent. by vegetable foods, of which 43 per cent is contributed by the cereals. Little fat is furnished by vegetable foods. Animal foods and dairy products are the most important sources of fat, milk and cream furnishing 26 per cent. of the total fat of the diet, and meat furnishing over twice as much.

The table does not show the relative amounts of the different kinds of foods which are expensive and which may be classed as luxuries rather than staples.

MAKING HOME STUDIES OF DIETARIES.

Any housekeeper who wishes to know how the nutritive value of the food she provides for her family corresponds with the dietary

Wheat on Ground Where Rye and Vetch Were Grown and Plowed Under the Year Before.

Wheat on Ground Where Canadian Field Pease Were Grown and Plowed Under the Year Before.

standards can easily make a simple dietary study in her home, and by so doing can perhaps not only provide meals that are more in accordance with the needs of her family, but frequently also save money by substituting less expensive but equally nutritious and attractive food materials for some of those usually served.

The simplest way to make such a study is to weigh all different kinds of food materials in the house at a given time, say after supper, recording the weights in a convenient book. All the food purchased during the days during which the diet is being studied is weighed and recorded, and at the close of the study, which may be conveniently of seven or ten days' duration, all food materials remaining on hand are weighed as before. From the quantities of the different kinds of food on hand at the beginning and purchased during the period are subtracted the quantities left on hand at the close of the study. The difference represents the amounts used. The quantity of nutrients in the different materials is calculated from the figures for percentage composition given in Table I. In order to express the quantities of nutrients in values per man per day, the number of meals taken by different members of the family are multiplied by the factors for age, sex and work, pointing off two decimal places. The result gives the equivalent number of meals taken divided by 3 gives the equivalent number of days for one man. The total nutrients for the whole period, divided by this latter quantity, gives the nutrients per man per day. From these latter figures the fuel value of the diet can be computed. In a similar way the value of any menu for one day or one meal may be calculated, but in a short period, such as a day or two days, the diet may vary according to the materials used so as to give more of one kind of nutrients and less of another, or more or less total nutrients than the average diet, while in periods of a week or ten days the diet is more likely to approach an average.

ADAPTING FOOD TO BODILY NEEDS.

All persons need protein for building and repair of the body and fuel ingredients for warmth and work, but individuals differ in amounts and proportions of requirements.

For people in good health and with good digestion there are two important rules to be observed in the regulation of the diet. The first is to choose the things which agree with them, and to avoid those which they can not digest and assimilate without harm. The second is to use such kinds and amounts of food as will supply all the nutrients the body needs and at the same time avoid burdening it with superfluous material to be disposed of at the cost of health and strength.

For guidance in this selection, nature provides us with instinct, taste, and experience. Physiological chemistry adds to these the knowledge—still new and far from adequate—of the composition of food and the laws of nutrition. In our actual practice of eating we are apt to be influenced too much by taste.

The theory is advanced from time to time that one or two meals a day are preferable to the three commonly served. The best physiological evidence implies that moderate quantities of food taken at moderate intervals are more easily and completely digested by ordinary people than larger quantities taken at long intervals. The very fact that the custom of eating a number of meals a day has so long been almost universal indicates that it must have some advantages which instinct, based upon experience, approves and justifies.

ERRORS IN FOOD ECONOMY.

Scientific research, interpreting the observations of practical life, indicates that a fourfold mistake in food economy is very commonly made. First, the costlier kinds of food are used when the less expensive are just as nutritious and can be made nearly or quite as palatable. Secondly, the diet is apt to be one-sided, in that foods are used which furnish relatively too much of the fuel ingredients and too little of the flesh-forming materials. Thirdly, excessive quantities of food are used; part of the excess is eaten and often to the detriment of health; part is thrown away in the table and kitchen wastes. Finally, serious errors in cooking are committed.

For the well-to-do the worst injury is that to health; but people of small incomes suffer the additional disadvantage of the injury to purse. With reasonable care in cooking and serving, a pleasing and varied diet can be furnished at moderate cost. It should not be forgotten that the real cheapness or dearness of a food material depends not only on its market price, but also on the cost of its digestible nutrients. It should always be remembered that "the ideal diet is that combination of foods which, while imposing the least burden on the body, supplies it with exactly sufficient material to meet its wants," and that any disregard of such a standard must inevitably prevent the best development of our powers. Some simple combinations will serve to show how few foods may be put together, and yet answer all requirements:

Menu I.—Whole wheat bread; whole milk; prunes.

Protein is furnished by both milk and bread; fat by milk and bread; carbohydrate by bread, milk and prunes; iron by prunes and whole wheat; calcium by milk and whole wheat; phosphorus by milk and whole wheat; magnesium and potassium by prunes, milk and bread; and bulk by prunes and whole wheat.

Menu II.—Cream of Potato Soup (or any vegetable soup having a milk foundation); bread and butter; fruit or a succulent vegetable.

When one has been accustomed to a larger variety, such meals may seem scant fare, but a little experimenting will soon demonstrate their practicability.

Any one of the following combinations makes a well-balanced meal if sufficient amounts of the foods are consumed. This does not indicate that they are ideal for all conditions. Persons who have a weakened digestion, babies and small children would not be given baked beans and brown bread, or bread and cheese.

Menu III.—Eggs; bread and butter; fruit or some vegetable.

Menu IV.—Oatmeal with sugar and thin cream or whole milk; fruit.

Menu V.—Baked beans, brown bread, apple sauce.

Menu VI.—Bread and cheese; onions.

Menu VII.—Meat; bread and butter; fruit or a succulent vegetable.

While the food combinations given above theoretically answer all dietary requirements they may not be practical in those cases in which food habits of long standing lead the individual to demand a greater variety. The appetite acustomed to stronger fare might pall if stimulated only with such simple mixtures.

Simple menus show the way for planning more complex dietaries, for whether the meal is to consist of bread, milk and prunes or is to be extended to include a dozen other things, the principle is the same, to combine foods rich in proteid, rich in carbohydrate and fat, rich in salts, and bulky watery foods. Thus instead of making a cream soup the main part of the meal, a small portion may be served at the beginning of the meal.

Menu VIII.—Cream soup; bread and butter; meat; potatoes; cabbage; baked apples and cream.

If a meal similar to the above is planned, in which the soup served is rich in nutriment and the main part of the meal is also rich in nutriment, it will be unwise to serve a heavy dessert. Apples, in this case, increase the bulk of the meal, give desired variety and taste but do not materially increase the calorie value which is already sufficient.

Menu IX.—Meat; potatoes; macaroni, bread and butter; bread pudding.

Menu X.—Eggs; mashed potatoes; baked sweet potatoes; custard pie.

The last two meals are poorly planned, not because they lack proteid, fat or carbohydrate, but because there is a deficiency of juicy foods. The meals are too rich in heavy foods and too poor in those which give bulk, mineral matter and fruit and vegetable acids. It is never wise to serve two starchy vegetables at one meal. If macaroni or rice or sweet potatoes are used they should take the place of white potatoes and not be substituted for the succulent vegetables as tomatoes, cabbage, onions.—(Dept. Agr. F. B. 142; O. E. S. Circ. 110; Cornell Read. Course for Farmers' Wives, New Series II, No. 6-7; New Series II, Vol. 1, No. 2; O. E. S. Bu. 29, 31, 37, 38, 52, 53, 55, 71, 75, 84, 91, 129, 149, 159, 223; O. E. S. Am. Report, 1906-1910.)

DRUGS AND DRUG LEGISLATION.

Drug investigation began in the United States before 1821. One of the chief objects of establishing the Philadelphia College of Pharmacy, 1821, was to direct attention to the quality of drugs brought into the market. The New York College of Pharmacy had for a series of years called attention to the fact that large quantities of sophisticated and misnamed chemical and pharmaceutical preparations were daily imported. The Pure Food and Drug law of 1906 shows the progress made since that time. There are many preparations on the market containing alcohol, morphine, caffein, cocain, chloral, hydrate, heroin (derived from morphin), acetanilid, antipyrin, phenacetin, opium and perhaps other such drugs. It was not an uncommon practice in former days to represent to the consumer that such agents were absent, when as a matter of fact the very drugs named in the disclaimer were present. The reason for this subterfuge is plain. No one desires to take preparations containing known habit-forming agents, which are frequently responsible for the use of, or demand for, the preparations containing them. During the last few years both federal and state laws have been enacted requiring a declaration on the label of the quantity or proportion of certain habit-forming agents when present in remedies intended for the treatment, mitigation, or prevention of disease in man or animals, but the consumer in many instances is not sufficiently conversant with the deleterious and harmful nature of these agents to avoid them. Again, these pernicious drugs are present in products which may not be classed as medicines within the meaning of the above definition.

The several classes of products will be considered as nearly as practicable in the order in which they are used, from infancy to old age. It should be stated at this point that only the most commonly used and known products of each class are considered here.

Soothing Sirups.—Soothing sirups naturally occupy the first place in such a list. Under this title be briefly considered baby sirups, soothing sirups, colic cures, children's anodynes, infant's friends, teething concoctions, etc. It has long been known to the medical profession that these products as a rule contain habit-forming agents, but the majority of mothers have been and still are ignorant of this fact, and give them with a certain feeling of security, with the result that in some instances the baby is put to sleep never to awake again. Numerous cases of this character are on record. In some instances, in which the remedy is freely used there is developed a case of infant drug addiction. As soon as the effects of one dose pass away, the child becomes irritable and fretful, with the result that another dose is administered, the craving is met, and the child is quieted, a condition which is analogous in every respect to drug addiction among adults. The following are representative of this class:

Children's Comfort (morphin sulphate.)
Dr. Fahrney's Pepsin Anodyne Compound (morphin sulphate.)
Dr. Fahrney's Teething Syrup (morphin and chloroform.)
Dr. Fowler's Strawberry and Peppermint Mixture (morphin.)
Dr. Groves' Anodyne for Infants (morphin sulphate.)
Hooper's Anodyne, the Infant's Friend (morphin hydrochlorid.)
Jadway's Elixir for Infants (codein.)
Dr. James' Soothing Syrup Cordial (heroin.)
Kopp's Baby's Friend (morphin sulphate.)

Dr. Miller's Anodyne for Babies (morphin sulphate and chloral hydrate.)

Dr. Moffett's Teethina, Teething Powders (powdered opium.)

Victor Infant Relief (chloroform and cannabis indica.)

Mrs. Winslow's Soothing Syrup (morphin sulphate.)

MEDICATED SOFT DRINKS.

There is another class of products not medicines which contain some of these same drugs. These are the so-called "soft drinks" sold at soda fountains, drug stores and such places. Quite a number now on the market contain both of the habit-forming agents, cocain and caffein. It is not uncommon to find persons addicted to the use of medicated soft drinks. It is also a well-known fact that many factory employees, stenographers, typewriters, and others subject to mental or nervous strain spent a large part of their earnings for drinks of this character. In passing it may be of interest to note that life insurance companies are considering the status of soft-drink habitues as future risks.

It is well known that parents, as a rule, withhold tea and coffee from their children, but having no knowledge of the presence of cocain, caffein, or other deleterious agents in soft drinks, they unwittingly permit their children to be harmed by their use. Manufacturers of drinks of this class, containing cocain, have been successfully prosecuted, for example, Koca Nola, Celery Cola, Wiseola, Pillsbury's Koke, Kola-Ade, Kos-Kola, Cafe-Coca, and Koke.

TREATMENTS FOR DISEASES OF THE NOSE AND LUNGS.

The number of remedies concocted for the treatment of these afflictions is legion. Their vaunted values are, as a rule, dependent upon the presence of certain powerful drugs, such agents as cocain, chloral hydrate, codein, heroin, morphin, opium, and tobacco being present. Most prominent among the diseases for which such remedies are offered are asthma, catarrh, colds, coughs, consumption, and hay fever.

Asthma Remedies.—The exact cause of asthma is not definitely known by the medical profession at present. There is no known treatment which will eradicate the disease. There are, however, a goodly number of specifics and cures exploited at present which have as their basic agents cocain, morphin, opium, or chloral hydrate. An example of the cocain type is Tucker's Asthma Specific, which consists of a solution of cocain, to be used as a spray with an atomizer. It is true that the amount of cocain introduced into the nose by means of a spray is small, but exceedingly small amounts are required, when used in this manner, to produce constitutional effects. In fact, this is the popular manner in which cocain is taken by those addicted to its use. They are commonly known as sniffers or coke sniffers because of the fact that the cocain is sniffed into the nose.

Ascatco, an opium, arsenic preparation, represented as an Austrian product, is also largely used as a remedy for asthma. Davis' Asthma Remedy, put on the market by a dealer in real estate, contains chloral hydrate; each dose contains from 1 to 8 grains.

Cold and Cough Remedies.—Colds and coughs are among the most common ailments of childhood and youth, and many special mixtures have been devised and placed on the market for treating them. These concoctions usually contain one or more habit-forming drugs, as is clearly shown by the following examples:

Acker's English Remedy (chloroform.)

Adamson's Botanic Cough Balsam (heroin hydrochlorid.)

Dr. A. Boschee's German Syrup (morphin.)

Dr. Bull's Cough Syrup (morhpin, later codein.)

Dr. Fenner's Cough-Cold Syrup (morphin.)

Jackson's Magic Balsam (chloroform and morphin.)

Kohler's One-Night Cough Cure (morphine sulphate, chloroform, and cannabis indica.)

Von Totta's Cough Pectoral (morphin and chloroform.)

The same habit-forming agents are offered to the public in the form of confections under such names as cough lozenges and pastilles; examples:

Linseed, Licorice and Chlorodyne Cough Lozenges (chloroform and ether.)

Linseed, Licorice and Chlorodyne Pastilles (morphin, chloroform, and ether.)

Pastilles Paneraj (morphin and codein.)

Such a practice is uncalled for, as efficient cough and cold remedies can readily be prepared without the use of these pernicious drugs.

Consumption Cures.—The exploiting of so-called consumption cures has apparently always been an inviting field to quacks. From the nature of the disease and the general information available to the public, it is only natural that persons so afflicted should grasp at the last straw. These remedies as a rule contain one or more of the well-known habit-forming agents, the action of which is to benumb the sensibilities and thus make coughing and some of the other symptoms less prominent and distressing, leading the victim to the belief that the medicine is actually bringing about the results claimed. The ravages of the disease are, however, neither checked nor abated in spite of the fact that the patient appears to feel better. On the contrary, the poisonous secretions, instead of being expectorated, are absorbed, thus increasing the poisons, or, as they are commonly called, toxins, in the body. The most disastrous feature of the scheme is that the unfortunate sufferer is robbed of valuable time which could be utilized to advantage in restoring his strength and health. It is well known that if treatment is begun early the disease can be arrested, but not by using these worthless and deceptive nostrums. Hundreds of thousands of dollars are spent annually in a campaign of education and in the treatment of this disease, and it is of the utmost importance to get control of the cases early, as there is little hope in the advanced stages. Some of the well-known remedies of this class are the following: Piso's Cure, a Remedy for Coughs and Colds, formerly known as Piso's Cure for Consumption (cannabis indica and chloroform;) Shiloh's Cure, formerly known as Shiloh's Cure for Consumption, Dr. Brutus Shiloh (heroin and chloroform); Prof. Hoff's Consumption Cure (opium); Yonkerman's Consumption Cure, called Tuberculozyne (heroin); and Gooch's Mexican Consumption Cure (morphin sulphate).

Headache Mixtures.—These mixtures are advertised as cures or effective treatments for many ills of mankind, ranging from cholera morbus in infants to brain fag and exhaustion due to drunkenness. They have been the cause of many deaths and hundreds of cases of poisoning. The amount of acetanilid, acetphenetidin, antipyrin, caffein, etc., used in preparations of this class of habit-forming remedies is very large. Until recently it was claimed by some that these agents were harmless and did not belong to the habit-forming group. The medical profession for some time believed that the depressing effects of acetanilid were counteracted by caffein, which is present in most headache mixtures, but experiments have shown that the assumption is erroneous. The caffein may stimulate the heart to greater activity for a short period, but the depression induced by the acetanilid is persistent and increases in proportion to the amount used. In many cases where these remedies have been used for some time or in large quantities collapse and even death have resulted. Several preparations of this class, in addition to the usual ingredients, contain codein, a drug which is replacing opium and morphin to some extent. Representative products of this class are: Royal Headache Tablets, Antikamnia and Codein Tablets, Ammonal with Codein and Camphor, and Sal-Codeia Bell. These remedies in general simply benumb or stupefy the senses, but do not remove the cause of the trouble.

Epilepsy Remedies.—One of the most pitiable and intractable diseases of mankind is epilepsy. There is no drug or mixture of drugs known to the medical profession which will eradicate the disease. These facts, however, do not deter the most ignorant from preying on these unfortunates. The various mixtures on the market contain one or more of the bromids, but a number contain, in addition, morphin or opium, the primary purpose of which is to create a demand for the remedy.

Tobacco-Habit Cures.—There are quite a number of so-called tobacco-habit cures on the market. All of them are ineffective, and some contain cocain in one form or another. Examples of preparations of this character examined and found to contain cocain and cocain derivatives are Coca Bola, Tobacco Bullets, and Wonder Workers.

Drug-Addiction Treatments.—With the exploiting and advertising of medicines containing habit-forming agents it is but natural to expect that drug addiction would result. There are at present mail order express treatments for all kinds of drug addiction. As a rule, these treatments are composed of well-known drugs. In most instances they contain the very drug or drugs for which the treatment is advertised and sold. For example, one physician furnished a treatment to a supposed morphin addict containing, according to his own statement, 22 grains of morphin to the fluid ounce, and in addition 4 minims of fluid extract of cannabis indica in the same amount.

Another doctor supplied a mixture containing on the average 14.2 grains of morphin sulphate to the ounce. A package sent out by the James Sanitarium for the treatment of a supposed morphin addict contains 24 grains of morphin to the fluid ounce. A treatment of Habitina contains 16 grains of morphin sulphate and 8 grains of diacetyl morphin (the chemical name for heroin, a derivative of morphin) to the fluid ounce. An interesting practice in vogue is the sending of a supply consisting of a number of bottles, marked from 1 to 18 inclusive, or whatever number there may be. In one instance, for example, 10 bottles were delivered marked first supply, numbered from 1 to 10, inclusive, and every one bore the same inscription, namely: Dionin 2 2/3 gr., morphin 4 gr. per fluid ounce. Each bottle held about 4 ounces of fluid, which means that it contained 16 grains of morphin and about 10 grains of dionin, a morphin derivative.

There are at present at least thirty of these treatments sold throughout the United States. They are sent indiscriminately into any home, although some of them contain sufficient poison to kill a dozen men, and in only one instance has the writer observed a statement of warning relative to their poisonous character.—(Dept. Agr. F. B. 377 and 393; Bur. Chem. Bul. 98, Rev. Part I.)

THE FARM HOME.

The proper situation of the farm home is of prime importance, so too are good building plans. These have been considered in other volumes. Ventilation, heating, lighting, plumbing, painting, sanitary surroundings, location of wells, outbuildings and disposal of waste, all so necessary have been taken up elsewhere.

There remains then to be considered the proper furnishing and decoration of the farm house that it may be in reality the farm home.

Every human being is responsible for making his own part of the world as beautiful as possible—by causing a flower to bloom where none had bloomed before, by ridding a doorway of unsightly weeds, by painting a weather-beaten surface of the house, by hanging a picture that will mean something in the life of the observer. This desire to beautify seems to be common to mankind; the person who has not this inclination may have become too absorbed in arduous duties to allow it to develop.

It is not enough that houses be merely built; after they are built they should be made homelike by means of serviceable furniture and purposeful decoration. The taste and knack of the housewife may make even the commonest homes attractive and restful.

Decoration is not mere ornament; it contributes to the making of a home picture. The artist with brush works upon canvas not merely to show certain paints. The housewife who adorns her home works for general effects, although attention may be centered on some particular object that is emphasized by a pleasing relation to its surroundings. Comfort and good taste are excellent motives in decoration. The first law of good taste is simplicity. Two kinds of flowers do not grow on the same stem, although we are sometimes guilty of placing a conglomerate mixture of flowers in one vase.

HOUSEHOLD DECORATIONS.

Unity of Effect.—Broadly speaking, a simple, united effect is the first quality to be desired for interiors whether the interior be one room or several connecting rooms through which vistas are seen. All parts of the home picture should harmonize so as to produce no sustained impression. Since the walls, ceiling, and floors of a room present greater surface than any of the furnishings they require first attention. Home should be a place of rest. There is small encouragement for relaxation in the sight of walls flaring with color, writhing with scrolls, or peering with spots. Therefore, if we are to have restful homes we must avoid using large quantities of colors that are strongly red or blue, for these demand of us too much nervous energy. Also all exaggerated patterns should be discarded. We have left then for use all sorts of quiet colors and modest patterns. These soft colors are called tones. By covering our walls with soft colors, or tones, we may unite into one harmonious effect the red of mahogany, the brown of walnut, the various shades of oak, and other motley colors present in mixed furnishings. This is an important problem in the average home.

If we stand off and look at a summer landscape we notice that, the great masses of leaves, grass, and grain, broken as they are by sunlight and shadow and softened by atmosphere, are only tones after all; and that brilliant colors are reserved for bits of accent or fleeting effects, as a bluebell, a yellow daisy, an orange sunset, or an autumn maple. These conditions in nature, if applied to our subject of home decoration, would suggest soft colors for all large surfaces as wall, ceiling, floor, and hangings, with accents of bright color in pictures, books, lamp-shades, and other small objects, as Nature uses her flowers. But do not get rooms too dark. Dark interiors, besides being gloomy, prevent the easy discovery of dust and dirt, and thus harbor germs and disease. A moderately light interior looks cleaner than a dark one and encourages better care.

All rooms, whether living-rooms or bed-rooms, which are northerly look best when the walls are of some warm color, as yellow, tan, buff, golden brown, reddish brown, old rose, or terra cotta, provided the furnishings harmonize. Rooms that are southerly need cool tans or buffs, dull browns and green, grays and gray blues. Rooms that are east or west allow of a wide choice of color, as they are both sunny and sunless according to the different times of the day. The amount of daylight, the amount of sunlight, and the furnishings and woodwork in a room, should guide aright our selection of color.

To most persons plain walls are less tiring than even a good figured paper. They also make the best background for pictures, as they do not compete with them in interest.

Water color paints, tints, or calcimines of whatever brand should be a great blessing to the farmer's wife, for they are inexpensive and readily applied by members of the family. They are especially good for bedrooms, being clean, soft colored, and easily freshened by a new coat. Oil paint with dull finish is equally excellent for bedrooms and other parts of the house, but is more expensive than calcimine or medium grade wall paper.

Floors.—Keep the floor moderately light in color. A golden brown is excellent (provided it harmonizes with the furnishings,) as it does not show dust or footprints readily. For this color use yellow ochre paint and a natural or medium dark oak floor finish. This light brown floor goes well with painted woodwork. The substitution of bare floors and rugs for carpets will go farther in easing general housework than any other one item. Next to bare floors, Japanese matting will probably be found most satisfactory to care for. Rugs may be used with matting, the same as with bare floors.

In general, rugs should be heavy enough to lie flat by their own weight without tacking. For a room that is used continually or by a number of persons, such as a sitting-room, one large rug is better than several small ones. Small rugs are suitable for bedrooms, fitted conveniently into the open spaces left by furniture. A rug should not extend under the bed, as this arrangement complicates cleaning. Rugs or mats placed before the bureau, the washstand, and the bed are comforting and necessary. A washable cotton mat is the most practicable kind for use before the washstand. Avoid large flowery or scrolly patterns in floor coverings. The material may vary from the expensive oriental rug to the humble rag carpet, but if the colors are quiet and harmonious a pleasing effect may be obtained.

Furniture, Its Construction and Design.—Every piece of furniture should serve some useful purpose. The construction should be strong and honest, and the shape of each piece should be a frank statement of its use. The material of which any given piece is made is of secondary importance to the straightforwardness of the design.

It is not because colonial furniture is old that it is valued so highly, but because it is well made of a kind of mahogany not now on the market. The designs are good. Any old pieces of mahogany may have the varnish removed and be refinished so as to be again beautiful. A few of the plainer pieces of walnut are good in design and are therefore permanent in worth. Walnut sets of chairs and sofa may be given a very good appearance by removing the black horsehair and using a lighter-colored upholstery in browns, greens, old gold, or old blue.

Stamped decoration of poor pattern, machine carving glued to panels, scroll-work brackets, and bended arms ending in animal heads, all these distortions should be avoided. Not one piece in one hundred should be left in this half-burned condition, but nearly all should be consigned to the flames for finishing.

Many of the mission pieces are clumsy, crude, uncomfortable, and weak in the joints in spite of their solid appearance, and the wood has in many cases been stained so dark as to kill the grain;

yet this wave of mission design has given modern furniture a trend in the right direction. There may be found on the market durable and appropriate furniture that compares favorably with colonial work in the solidity of its construction and in the refinement of its form and finish.

CARE OF THE HOME.

In the elaborately furnished house of the present time, the best sanitary conditions are well nigh impossible. They are too full of things—too much bric-a-brac, too many pictures, too much draperies, upholstered furniture and heavy carpets. Light and air have not free access, dust finds many lodging places, and last, but not least, the housekeeper's life is a burden to her. Let us sacrifice elegance on the altar of comfort and cleanliness. It is with the germ life in its many forms that the sanitary housewife has to do. Some of these attack the human body and cause disease; others work in our kitchens and pantries. The war against dust must be evermore waged, so simplicity of woodwork and furnishings is desirable. Hardwood, stained or painted floors with rugs easily lifted and cleaned, walls smooth and easily cleaned, windows not so much shaded and draped that sunlight and fresh air are denied entrance, and upholstered or much carved furniture reduced to the least possible point, all these things count for much in the housekeeper's work against dust and dirt.

Dust will form in any room where people live or congregate; but we do not have to breathe it in quantity, if sweeping and dusting are done in a proper way; that is, in such a way as to lay the dust, instead of filling the air with it. Dusting is best done with a damp cloth and floors too, may be be wiped up frequently so as to reduce sweeping to a minimum.

The housekeeper's problems are many and great care is needed not only to keep her home clean, but to see that this cleanliness is so far-reaching as to make it sanitary. Dust, aside from its untidiness, brings danger for it carries germs of decay and disease; flies are not merely inconvenient and annoying, they too are carriers of disease; mosquitoes formerly considered only troublesome are now recognized as the means of spreading both malaria and yellow fever. The ticks of Montana have been proved to transmit spotted fever, but fortunately are confined to bushy hillsides and rarely enter the house. Fleas, bedbugs, and other insect pests not only feed on our blood but may infect us with noxious disease. In our Southern States an eye disease, pink-eye, is carried from one to another by certain very minute flies. Rats and mice not only steal our food and destroy our property but threaten our lives. Rats harbor fleas and as they are some times affected with the dread disease known as the plague, these fleas may later bite persons and inoculate them. The housekeeper must bear all this in mind and by cleanliness, careful covering of all foods, careful exclusion of all insect pests, and protection from rodents, she will be able to protect herself and family from infection.

Probably the greatest danger comes from house flies. This is perhaps greater in the country than in cities. The female house-fly deposits her eggs in horse-manure when possible—but if this is not available seeks other manure or even human excrement. As it takes only 10 to 15 days for the eggs to mature into full grown flies, there can be five or six generations in a season. The reason they are so very abundant about September is due to the fact that no care whatsoever is taken to have all the piles of horse-manure removed during the summer so that there will be no substance on which the female flies can lay their eggs.—(Cornell Sch. Leaflet, Vol. III, No. 2.)

The adult fly visits all sorts of filth, manure, slop-pails, pig-pens, decaying animals and plants, among which it finds its food. Unless windows and doors are properly screened, flies are constantly passing from the filth to the kitchen and dining room, walking over the food. In passing over the filth, thousands of bacteria cling to the hairs on their bodies and legs and to the pads on their toes. A part of these bacteria are left later on our food or washed off in the milk that we drink. If there should be among the bacteria those producing typhoid fever, tuberculosis, or any one of the numerous bacterial diseases to which man is subject, the possibility of his taking the disease would be very great. The house-fly is so important a factor in the carrying of typhoid fever that an eminent entomologist, L. O. Howard, urges that in the future this insect should be known as the typhoid-fly. It is significant that the smaller round colonies from fly tracks are often flies of a kind of bacteria *regularly present in human excrement.* There are a few other flies which are attracted to and which may breed in human excrement that also have to be guarded against. The care of human excrement, however, will prevent the carriage of typhoid germs even by these species. The little fruit flies which breed in overripe or decaying fruit, are the principal species in this category. Therefore, fruit storehouses or fruit receptacles should be screened, and overripe fruit should not remain in dining rooms or kitchens for any length of time.

Mosquitoes are of several kinds. They breed in swampy regions, still pools, irrigation ditches, sometimes in old horse-troughs and rain-barrels. These places may be drained, covered with a little kerosene, or stocked with fish that eat the larvæ. All houses should be carefully screened and one should avoid remaining outside where they abound. Fortunately most mosquitoes are simply annoying. Culex is the common variety, anopheles the malaria carrying one. Culex has clear wings, short palpi (the projections on either side of the beak) and appears humpback when resting on a wall, that is the head and beak project toward the wall and are not in line with the body. Anopheles has spotted wings, long palpi, and rests with head and beak in line with the body.

How Germs of Disease Are Scattered.—In general disease germs leave the body of the patient through excretions of some sort. For example, the germs of tuberculosis and diphtheria in expectorations; of typhoid fever in the excrement and sometimes in the late stages of the disease, in the urine. Accordingly the first sanitary precaution consists in the proper care and disposal of these various excretions. Physicians direct the disinfection of the sputum of patients known to be suffering with tuberculosis; but many persons, through willful disregard, or in the early and unrecognized stages of the disease, spit freely, on the floor and on paths and sidewalks. The sputum dries and becomes dust; and the germs are, therefore, easily blown about and settle wherever dust settles.

The Dangers of Dust.—The presence of dust, especially in public places of assembly like school houses, halls, and churches, is a menace to health, and so far as possible should be avoided. The school is a natural mingling place for the germs of a community, and it is time that parents, teachers, and pupils should combine to make it the most ideally clean place in the neighborhood. Attention has often been called to the fact that diseases of children point to the school as the great center of infection.

SUMMARY.

By careful attention to a few common sanitary measures you can improve the health of your household and avoid certain diseases.

1. See that your well is properly located and constructed, so that disease germs can not get into it.
2. See that your privy is properly located and constructed, so that disease germs can not get out of it.
3. If your water supply is not safe and you can not easily make it safe, boil or distil your drinking water.
4. Keep an eye on your milk supply. Pasteurize or heat milk if it seems desirable.
5. Avoid drinking out of public drinking cups, and avoid other promiscuous habits.
6. Keep flies and mosquitoes out of your house. Use screens; they are cheap.
7. Keep an eye on the sanitary condition of the public buildings of your community; especially of the school house where your children go; look out for privies, water supply, and dust and dirt inside.—(Bul. 89.)

DISINFECTION.

By disinfection is meant the absolute destruction of the germs of infectious diseases. If this is done by means of chemical substances these are called disinfectants or germicides. An antiseptic is a substance which prevents decomposition by preventing the growth and multiplication of germs, but does not destroy their life necessarily. All germicides are antiseptic in weak solutions, but there are many substances which are good antiseptics, though not germicides in any strength. Examples are common salt and sugar, both of which are largely used in preserving meats, fruits, etc. Sterilization means the destruction of all forms of life in or upon the surface of an object. When an object is sterilized it is also disinfected. Deodorants either mask or entirely remove disagreeable odors. Some deodorants are good disinfectants, and some disinfectants good deodorants. For example, charcoal is a good agent to remove smells from putrefying material but does not kill the germs which cause the putrefaction. Formalin is a true deodorant as well as a disinfectant, as it not only destroys bad odors but also kills the germs producing them. As a rule it is better to employ an antiseptic or germicide which has no smell of its own, as there is danger that the real state of affairs may be hidden or masked by the pleasant odor of the deodorizer, while the putrefactive process goes on without hindrance. Many such substances are sold as disinfectants though entirely worthless. It must be remembered that bad smells do not always accompany dangerous processes; and on the other hand, that the ordinary putrefactive processes, which give rise to very offensive odors, often destroy virulent disease germs.—(Wis. Exp. St. B. 166.)

Thorough cleaning will often make disinfectants unnecessary but no amount of disinfection will take the place of cleanliness. In cases of contagious diseases both cleanliness and disinfection must be employed.

The market is flooded with commercial disinfectants put out by private manufacturers. Many make absurd claims for their material. In buying these disinfectants one is apt to pay much more than their true value. It should always be remembered that no one firm has a monopoly of chemical disinfectants. All commercial disinfectants depend on well known chemicals for their action. A few manufacturers have succeeded in preparing these chemicals so that they are easily handled and have certain advantages over the substances on which their value depends, but as a rule it is better to buy the chemicals and not some private commercial preparation of them.

The action of a disinfectant often depends largely on its solubility in water. For example, some oily substances have considerable power but do not dissolve readily in water, nor mix with it. A good example is found in the cresols, which are the basis of many commercial preparations. The general usefulness of these valuable agents is much increased by combining them with soaps as in creolin, lysol, etc., which mix readily with water in all proportions.

For complete disinfection of a room the gaseous disinfectants are the best, for the reason that the gas permeates every nook and corner reaching places that would not be touched in any other way. It is plain that the room must be tightly sealed to prevent the escape of the gas. This is easily done with strips of heavy wrapping paper and ordinary flour paste, put on with a paint or white-wash brush. It is easily washed off and leaves no mark.

Medicated soaps are usually worthless and should not be trusted. Most of them are not as good as ordinary soap alone. Soaps are useful mainly in making substances soluble, and assisting in cleaning surfaces, garments, etc.

No one should feel dependent on commercial disinfectants for nature has provided very powerful agents for the destruction of disease producing germs.

Sunlight is one of the most powerful germicides known, destroying not only the growing germ but also the spores. If we had means to carry sunlight into every corner of our barns and houses, there would never be any need to buy chemical disinfectants.

The germs of consumption, diphtheria, typhoid fever, plague, and in fact the germs of all diseases yet discovered are killed by direct sunlight in six to eight hours. Some die after a few minutes' exposure. If germs are protected by blood, filth, etc., they are not killed so quickly.

Many disease germs are killed by the light which reaches them in an ordinary room but this diffused light is not nearly so powerful as direct sunlight and it usually requires several days to destroy life. However, the important lesson is taught us that well-lighted rooms do not harbor contagion. Good ventilation and light are important aids to any system of house or barn disinfection.

Heat may be employed dry, as by baking in an oven, or moist, as in boiling or steam. Dry heat is not as efficient as moist heat, and has not as much penetrating power. Boiling destroys disease germs as well as spores in from five to ten minutes. It is especially useful for disinfecting clothing, bed-linens, handkerchiefs, cups, plates, spoons, etc. Boiling water is also very useful for floors, walls, and furniture. The addition of lye or strong soap helps its action very much.

Steam is the most efficient method of applying heat. It destroys all forms of bacteria and spores very rapidly, and has great power of penetration. Steam under pressure is still more powerful. It is apt to injure woolens and silk, and ruins leather, furs, and rubber articles, like shoes and mackintoshes. Burning of course destroys all infectious material, but the practical application of fire is limited.

Well-Known Chemical Disinfectants.—Bichloride of mercury, mercuric chlorid, commonly known as corrosive sublimate, is one of the most powerful germicides known. It is a deadly poison to man and must therefore be used with the greatest care not only in the house but in the barn. Many manufacturers make tablets of corrosive sublimate combined with chloride of ammonium, or common salt, which are easily soluble and more efficient than the drug alone. Directions are given for making a solution of any strength desired. These can be bought at any drug store. Almost all germs which do not have spores are killed in a half hour by a solution of 1 part corrosive sublimate in 1,000 parts water. To kill spores a 1 in 500 solution must be used and one hour of time must be allowed.

Bichlorid of mercury is a violent poison, and has the property of combining with albuminoids to form inert compounds. It should never be used to disinfect excreta, or substances containing blood or serous fluids. Bichlorid solutions should not be kept in lead or tin vessels, or poured through lead pipes, as the mercury combines with these metals and injures them, besides affecting the germicidal efficiency of the solution itself.

The chief advantage in the use of bichlorid of mercury lies in its great germicidal power when employed under proper conditions. The disadvantages are its poisonous nature, its tendency to attack certain metals, and the interference by albuminoids and other organic substances. Antidote. Egg whites and milk in abundance.

Carbolic acid is widely used and has many good qualities to recommend it. It can not be depended upon to kill spores but it destroys all other disease germs rapidly. It does not injure any articles of clothing, nor metals. It is poisonous, however, and must be used with care. A saturated solution is close to 5 per cent, the strength in which it is usually employed. Such a solution is useful for the disinfection of sputum from consumptives or persons with pneumonia and for the discharges of typhoid fever patients. Equal portions of the solution and the material to be disinfected must be well mixed together and allowed to stand at least two hours.

The Cresols are more powerful than carbolic acid and form the basis of many disinfectants. What is known as Trikresol is sold at most drug stores, and is a very efficient germicide for all purposes. The cresols are widely sold in preparations which will mix with water in all proportions. The best of these are known in trade as Creolin, Lysol, Solveol and Solutol.

A 2 per cent solution of cresol is as efficient as a 5 per cent solution of carbolic acid. It is not interfered with by albuminous substances. Is cheaper than carbolic acid and does not destroy metals or fabrics in a 2 per cent solution. It is more effective than carbolic acid for destroying spores of bacteria, such as anthrax. The main drawback to the use of cresol is that it is not readily soluble in water, hence may be used in too weak solution unless great care is taken in the preparation of the solution.

Lime is one of the cheapest and most useful disinfectants that we have. It has the power of destroying organic matter as well as bacteria and is therefore very useful in the disposal of the bodies of animals which have died of contagious diseases. For disinfection it is best used as milk of lime. In preparing this quicklime must be used. Slake by adding a pint and a half of water to each quart of lime. The result is hydrate of lime—a dry powder. One quart of this is mixed with four quarts of water.

This must be freshly prepared to have any germicidal power. It may be kept two or three days if tightly corked. Milk of lime is very valuable for disinfecting the discharges of patients with typhoid fever, dysentery or cholera. At least an equal volume of the lime must be added and well mixed with the discharge, the whole being allowed to stand two hours.

Whitewash is the same as milk of lime and when made from freshly slaked lime is equally good if the same proportions are used in mixing.

Chloride of Lime (Bleaching Powder) chlorinated lime, is widely sold for deodorizing and disinfecting purposes. When freshly prepared or carefully preserved in air tight packages, it is a very useful agent. It may be employed as the powder or in solution. It is used to disinfect discharges and for scrubbing floors and woodwork.

Formaldehyde Gas is one of the newer germicides and is perhaps the most useful disinfectant for general purposes known. It is irritating to the eyes and throat, but is practically non-poisonous.

CROP ROTATION IN MARYLAND—GRASS, COWPEAS, AND CORN.

(See pages 201-219.)

VIRGIN SOIL READY FOR PLANTING TO WINTER GRAIN.

It can be used freely in the finest rooms as it is non-corrosive and does not injure pictures, clothing or even the most delicate fabrics. It is also a true deodorizer, uniting with the products of decomposition to form new compounds which are free from odor and sterile. Formaldehyde is sold in most drug stores and may be obtained under two forms, formalin and paraform. Formalin is a solution of the gas in water and should be 40 per cent strong. Paraform is sold in tablets or cakes. An excellent method for disinfecting a room consists in suspending a number of sheets on cords stretched from wall to wall and spraying these with undiluted formalin. Not less than ten ounces of formalin must be used for each 1,000 cubic feet of space. A sheet will take about five ounces of formalin without dripping. This method is almost useless in a cold room. It should be employed only in warm weather or in a heated house. The temperature should be above 65 degrees F.

When permanganate of potash is mixed with formalin a violent reaction takes place and formaldehyde gas is liberated rapidly, almost the total amount of available gas being given off within a few minutes. It has been shown by experiment that a large quantity of gas with short exposure is more efficient than a small quantity with long exposure. For simplicity and efficiency this method is superior to all others.

Place the proper amount of permanganate in a suitable vessel and pour the formalin over it. Ordinarily ten ounces of formalin must be used for each 1,000 cubic feet of space. For every ounce of formalin, one-half ounce of permanganate must be used. For instance, if our room contains 1,000 cubic feet of space, we use ten ounces of formalin and five of permanganate. On account of the frothing which occurs, a deep vessel should be used, and not more than a pint of formalin be used in a single vessel. The ordinary galvanized iron or tin bucket may be used conveniently, employing several if the room is large. The gas begins to come off almost immediately, forcing the operator to leave the room at once. On account of the heat generated, it is well to place the buckets in shallow pans containing water. The gas occasionally takes fire, hence there is some danger in this method. The buckets must therefore not be placed near curtains or any inflammable material, and must be watched for a few minutes. If fire does not appear within the first few minutes the room can be closed with safety.

Paraform is sold in tablets, or in cakes. A common trade name is solidified formaldehyde. Lamps of cheap construction are usually sold with it, and some manufacturers put out a disinfectant consisting of a cake of paraform in a tin container with a paraffin candle beneath. Paraform is used by heating. It first melts, then goes off as formaldehyde gas. It catches fire rather easily, burning with a blue flame. It has no disinfecting power when burned. This method can be recommended only for small rooms, closets, etc. It is cheap and easily handled. All cracks must be carefully sealed and the room or closet kept shut twenty-four hours. At least two ounces of paraform must be used for each 1,000 cubic feet of space.

The burning of sulphur is one of the oldest methods of disinfection known, but has been almost entirely displaced by newer and more reliable methods. It kills only on the surface and does not destroy spores. It is very destructive to animal life, killing insects and vermin, and is especially useful in destroying contagion spread by such agencies. In order to act at all, sulphur requires the presence of moisture. The method has the advantages of cheapness, ease of application, and procurability. Sulphur can be bought in one form or another everywhere. It bleaches many dyes, corrodes metals and weakens almost all fabrics.

Sulphate of Iron commonly know as copperas, green vitriol, or iron vitriol, has for many years been widely used as a disinfectant. The accurate tests which are now made have shown that it has practically no value as a germicide. It is a fairly good deodorizer, but must not be depended upon as a disinfectant.

ECONOMY IN HOME MANAGEMENT.

It is essential that the necessary routine work of the home should be made easy if the home maker is to have time, energy, and enthusiasm for her home life, and there is perhaps no place in the home where more unnecessary time and energy are expended than in the ordinary kitchen, owing to faulty planning and inconvenient construction and furnishing. In a model kitchen exhibited at the Missouri Housekeepers' Conference at the Agricultural Station an effort has been made to secure economy in steps taken and in the time and energy required for housework.—(F. B. 269.)

This plan, as outlined below, may perhaps serve as a guide in remodeling or rearranging some of the kitchens already built. This kitchen contained a modern kitchen cabinet, a refrigerator with an out-door opening to receive ice, an outside pantry window box for use in cool weather, a small table on rollers, an ironing board hinged to the wall so it can be put up out of the way when not in use into a wall cabinet, with shelves below for irons, holder, wax, etc., a high stool and one comfortable chair. Ironing board, sink, and table as well as wash tubs should be high enough so the worker will not have to stoop over. Better to reach up a little than to cramp and compress the lungs by stooping over. This stooping puts too much strain on the back. If eatables must be kept in the cellar a dumb waiter may easily be made to save going up and down stairs.

A WINDOW PANTRY MAY BE MADE EASILY.

A dry goods box the size of the lower sash is fitted into the window from the outside and fastened to the casing. Holes are punctured in the box, or wire netting may form one side for ventilation. When the window is lowered, the provisions are kept as cool as the outside air, and near the place where the work is done.

THE HAY BOX OR FIRELESS COOKER.

In the German army for some years the hay box has been used to advantage and it is recommended to housewives as a means of saving fuel, labor, and food. It is especially good for slow cooking or steaming.

Such cookers may be readily made at home, and even when they are of very simple construction they have given good results provided they are well packed with insulating material. A tightly covered tin or enameled can or bucket or a kettle preferably without a handle, but having a tight cover and a wooden box and packing material are the essential features. The packing box or other receptacle should be considerably larger, say 3 or 4 inches in every direction, than the vessel used for cooking. Line the box with several thicknesses of paper or with asbestos. Over the bottom of the box should be spread a thick layer of hay, crumpled newspaper, or similar material tightly packed. The cooking vessel is placed on the center of this and the spaces between it and the sides of the box packed full of the hay or excelsior. A thick cushion or pad of suitable size should be made for covering the top of the can and also a wooden cover for the box. In some of the cookers which have been described in magazines, etc., thick felt, asbestos, cork, and other nonconducting materials have been used for packing, but good results have been reported with the simpler materials. A trunk makes a good cooker. So does an old chest.

These cookers may be made to hold one or more cooking vessels, and in case space is desired for two or more it is convenient to divide the box into compartments.—(F. B. 296.)

The food which is to be cooked is brought to the boiling point in the can or bucket and cooked for a short time, two or three to twenty minutes usually, or perhaps ten minutes on an average (though the time depends upon the material and should be learned by experience), and is tightly covered and placed in the nest and covered on top with the cushion and the lid of the box closed. The cool air of the room can not pass through the packing to the can nor can the heat inside it pass through the nonconducting material, except very slowly, and so the food remains hot for several hours and cooks thoroughly and evenly without further attention. About twice as much time is required as in cooking over the flame. There is little evaporation, so care must be taken not to use too much water in preparation. Many articles of food are better for long, slow cooking, and as neither fire nor attention is needed (after the initial heating) it proves an economical means of preparing food for the table. There are no noticeable odors from the cooking food. The cooker must not be opened from the time the food is placed in it until it is needed for serving, as the removal of the covering, etc., would mean an escape of heat.

By means of this cooker a breakfast cereal may be prepared by boiling it a few minutes in the evening, then packing it away in the cooker, and in the morning it will be ready for use. Soup can be prepared early in the day and will be ready for luncheon. Chicken, macaroni, stews, boiled ham, fruits, especially dried fruits as prunes, rice, vegetables, etc., can all be cooked in this home made cooker. A little experience will enable one to use it for many things.

An arrangement, which saves time, locates at a glance just where to find the cinnamon, rice or red pepper. The difficulty is in getting bottles with close fitting stoppers, and in the expense of the bottle. It may be well to consult the druggist regarding good bottles for this purpose. Mason jars do well. A mangle for the household ironing may be a paying investment. These may be had costing from $15 to $40 and run by gasoline, gas, electricity or some are made to iron simply by the pressure brought to bear on the rollers. Only flat clothes are run through the mangle, but the time taken for their ironing is so much less than that required by the usual method that the mangle is paid for in a comparatively short time. Unless the fire is kept up for other purposes, there is also a saving of fuel. Many who are situated where they can use gas or electricity are buying the flat-irons which are heated by these means. A new iron is on the market which is run by the burning of denatured alcohol and there are also irons heated by charcoal. The value of these irons is mainly in saving the heat and the travel from the ironing-board to stove.

Although alcohol is far less dangerous in use than gasolene as far as probability of explosion is concerned, there should be no misunderstanding respecting the fact that it is an explosive substance both when in the form of vapor and when mixed with air, and all the precautions which are used in the case of gasolene should be employed also with alcohol.

A CABINET FOR HOME BAKING.

A simple cabinet for controlling temperature during the dough stage has been devised by the Household Economics Department of the Ontario Agriculture College. It is 2 feet 8 inches high, by 2 feet 2 inches broad, by 2 feet deep, outside measurements. The whole is lined with asbestos, and divided into upper and lower compartments. The partition is placed high enough to allow a small coal oil lamp to be placed in the bottom compartment. The lamp is used as the source of heat, and the heat is transmitted through water contained in a shallow covered galvanized iron pan placed in the center of the partition. The fumes from the lamp are allowed to escape through small holes in the wooden frame below the partition. The top compartment may be used with or without slatted shelves, and may be kept at any desired temperature by raising or lowering the flame of the lamp, thus influencing the temperature of the water, and consequently, that of the compartment. A very small lamp with the wick turned as low as possible is usually sufficient to maintain the temperature at from 70° to 80° F. The thermometer should be left in the cabinet and the temperature noted from time to time, and the flame of the lamp so regulated as to give a constant desired temperature.

The cabinet may be made any desired size, and may be so arranged that the top will answer as a kneading board, and pans and other utensils may be kept in it between baking days. By the use of such a cabinet it is possible to maintain the dough throughout the fermentation period at any desired temperature, and thus render it possible to control one of the main sources of worry and uncertainty in breadmaking. The asbestos is used to reduce the danger of the case taking fire if anything happened to the lamp, and also to check any draft through the cracks of the box. If the box is tight, and the danger from the lamp overlooked, there would be no necessity for lining the box.

A few other conveniences may be mentioned such as sharp knives, a fine grain scythe stone, good egg beaters, lemon squeezer, measuring cups, a palette knife to scrape bowls and kettles, sink and vegetable brushes, a covered pail for kitchen scraps, and shakers for salt, pepper, flour and sugar. And lastly every kitchen should be supplied with a good cook-book—to be used for suggestions and in the preparation of new food materials.

Of course the sewing machine will be found in every home and there should also be a carpet sweeper, self-wringing mop, a power laundry if power is used on the farm or at least a good washing machine, bread mixer, and a clock.

It is surprising how many steps may be occasioned by the necessity of going from the kitchen to the family sitting-room to determine the time of day. Much of a woman's work is regulated by the clock, and one in the kitchen is about as necessary as a dishpan or a broom.

One Other Way of Saving Steps.—Teach the children of the household to assist in the work. This is as great a blessing to the child as to the mother. The little step-savers of the household are blessings to many a home-keeper.

A Home-Made Shower Bath.—A shower bath for summer use can be arranged in one corner of the wash room or, for use of the boys, in the barn. The material necessary for constructing it are enough pipe to connect to the main pipe of the stock tank, a stop-cock, a box supported on brackets and lined or not as seems best, and a perforated pipe for the shower.

One of the most important things for women to learn is to save strength from daily tasks for the emergencies of life. To use the limbs to save the back, as in lifting and even walking, to stand and sit at one's tasks so as to give lungs and vital organs freedom and a chance to do their work. To learn to relax. From time to time sit down even if some task is still undone, take a look at the fine sunset outside, visit the garden or orchard for recreation. She was a wise woman who said: I have so much to do that I do not know where to begin, so I will take my nap and get that much off my mind.—(Dept. Agr. F. B. 269, 296, 317, 353, 270; Mo. E. St. Cir. 30; Ontario Dept. Agr. Bul. 180; Cornell Reading Course for Farmers' Wives, Series I, Nos. 1 and 3; Series VI, No. 28.)

CLOTHING.

In the matter of clothing the same standards are set as in the decoration and furnishing of our home. Three things must be considered, the uses for which clothing is intended, the quality of the material, and the beauty. The last depends on the first two. Honesty and simplicity in clothing, adaptation to the needs of the wearer, and freedom from muscular restraint, neatness and trimness is just as desirable as cleanliness. The movements of the limbs and respiration and all abdominal functions are hampered by long skirts and tight clothing. Dress is one of the most potent factors that tend to debar woman from outdoor activities. And the lack of outdoor life is among the most powerful reasons of the lack of vitality in women. And yet if the average girl had not been taught from babyhood to put this matter of clothing the body to the forefront of all other considerations, she would be able to think sanely and give it the right value. Children especially should be dressed so as not to interfere with their activity. The little girls should be allowed as much freedom in muscular activity as the boys. Rompers are very good but there are other simple dresses which may be used, especially for older girls.

All articles of wearing apparel should be kept in places where they will be out of sight and out of dust. A closet or a wardrobe will be needed for every bedroom. If a room is not provided with this convenience, a wardrobe may be built of matched boarding and finished to correspond with the woodwork of the room; or it may be made of burlap or of denim stretched tightly over a wooden framework, with a curtain at the opening. An ingenious home-made device can always be fitted up for a closet, care being taken to make it as dustproof as possible. A closet should be at least two feet deep and should be provided with a rod supplied with coat and skirt hangers for the various garments. Clothing may thus be kept in shape and free from wrinkles, and more articles can be hung in a given space than by any other arrangement. A long, narrow closet prepared in this way will furnish more hanging space than will a square closet of greater size. A shelf above for hats and another below for shoes will complete the outfit. A closet that one reaches rather than steps into may be provided with a strip at the threshold to keep out the dust. The closet should be finished white or very light inside, so that garments may be easily seen and selected and moths may be detected. Closet space may be supplemented with boxes of any desired size, covered with cretonne or matting, fitted with hinged lids and made the height of a seat, thus answering two purposes.—(Cornell Reading Course for Farmers' Wives, Vol. I, No. 7, Farm Home Series; Mo. Exp. St. Cir. 30; Canada Rept. of Women's Institutes, 1912.)

DOMESTIC RELATIONS.

Nothing gives zest and interest to housekeeping so much as the intelligent application of principles that save time and labor. Housework without thought is drudgery; with it, there is delight in the accomplishment of those duties that transform housekeeping into home-making. The housewife is often an all-round intelligent worker who must perforce crowd into her busy day work belonging to a dozen different professions. The gracious lady who receives her guests with a heartsome welcome is also the capable cook, the exquisite laundress, and the artistic housekeeper.

The most useful life may be made up of these details. The spoke of a wheel is only one stick of wood, the hub a larger piece fashioned to receive the spokes, the tire but an iron band to hold all in place. Without the spokes, the wheel lacks strength; without hub, the very center is lacking; without rim, the wheel has no stability. These domestic trifles are the condition of man's mightiest achievements, or are very possible elements in his defeat. A soggy potato has weighted many a man's soaring ambition. A complaining word, a sour look, or bitter tone, has taken the heart out of a man. Poor coffee has dampened the ardor of many a poet.

We have seen how by proper selection and preparation of food available, the body may be well nourished and rendered capable to perform its duties; how by proper arrangement of our houses we can obtain light and air and reduce the dangers of disease; how by scientific methods we can preserve ourselves and our children from contagion; how by the use of suitable furnishing and decorations we can reduce the labor in caring for our homes and at the same time increase the beauty and restfulness of such homes. By the thoughtful application of the principles governing each task or activity we can so manage our affairs as to give time for study and recreation. To be well poised, calm, and efficient will be conducive to better domestic relations. When each member of the household is kept in health and strength, lives in a quiet orderly home, has the advantages of open air life, is suitably and comfortably clothed, and has time from daily tasks for pleasant recreation, there is little to cause friction and home will be a cheerful place. No one will care to leave it.

Recreation and amusement are essential features of a normal life and are as much the right of the farmer's family as of those who live in larger communities, to whom music, art, and many other forms of recreation involving high ideals are more conveniently accessible. However, by means of books, farmers' institute work, lectures, traveling schools, clubs for home study, etc., much that is really best is within the reach of all. The lightening of home burdens by means of a well-equipped and hygienic house, by the use of household conveniences, and by the proper understanding and systematizing of home work, means that the home maker and her family may have opportunity for something beside the daily tasks which too often leave neither time nor inclination for recreation.—(F. B. 317.)

There is much that can and ought to be done with our leisure moments. We may have more time to be the companions and associates of our sons and daughters. Give them the right ideals of home life so that they may go forth better equipped to make their own homes ideal. We may visit a neighbor ill or in trouble, or visit the teacher in her school and help her solve her problems by showing a helpful intelligent interest in her work. We may read a good book or magazine article, learn some song or poem, or prepare a paper for our club. Then too there are the broader community interests to engage attention. Have you solved some problem of management in your home? Have you invented some labor saving device or made new use of an old one? Pass it on. Perhaps some one may need the result of your experience. Perhaps some one can aid you! Farmers' Wives Clubs, Women's Institutes, Study Clubs

—all these give opportunities for helpfulness. The Pure Food Committee of the State Federation of Woman's Clubs has especially requested the inspection of dairies, bakeries and meat stores and desires that the reports on same be distributed.—(Ky. Sta. Bul. 119.)

The farmer's wife has the same need of study to keep abreast of the times, to keep up with her children, and to preserve a joyous spirit, as does the woman living in the midst of libraries, picture galleries and lecture bureaus. Her early education, like that of her city sister, needs constant polishing to keep it bright, and her sympathies need to expand rather than to grow narrow and insignificant. The very practical nature of the farmer's wife's occupation makes it desirable to base that occupation on scientific principles as well as to relieve it with a thought of poetry, history or fiction.

Let some woman take the leadership, see the other women of the community and arrange to meet on a certain date, either in a home, at the school building, or in the grange hall. The meeting may be held when the men have their club meeting, or alone, as seems most practicable. Make the organization as formal or informal as you please. Allow no discussion of topics during the program hour except those selected for the evening. The President should hold all members to a stringent observance of the rules in order to make the meetings a success.

It is well to have the men present at these meetings and to ask them to take part in the program, but it is suggested that they may retire to another room and discuss agricultural subjects while the women are on the domestic problems, or that time be given to them for a discussion of their own subjects to which the women will doubtless be interested listeners. The men can doubtless throw much light on the domestic problems of the home. Elect a chairman. Draw up a few rules by which each meeting shall be governed. These may be added to as the occasion demands. Each club will need to be governed by its own local conditions.

Then there are the school clubs just as important in rural communities as in cities. What is the sanitary condition of your school? Where does the drinking water come from? How is it heated, lighted, ventilated? Has it a school garden? Where do the children play, eat lunches, and study? What can be done to better conditions? Does the rural school education satisfy your ambitions for the boy and the girl in your home? Can you make them happy and contented to remain on the farm where their help is so much needed, if there is not offered in this day of progress a larger outlook and a better acquaintance with improved methods in farming?

Not all of the children attending the rural school will remain on the farm. They may be better fitted for other callings. The large number who do remain should have instruction in practical matters related to their every day living.

Young men and women going from the rural school to the college should not be handicapped by scanty preparations in English, practice in taking notes on lectures and the ability to express themselves easily. Experience proves agricultural students to be earnest and capable, winning the respect of their fellow students. Let the rural schools prepare them for standing shoulder to shoulder with those educated in larger schools and outstripping them if they can. This means a larger pride in the rural school, greater care to secure practical teachers, more expenditure of money for healthful conditions and better supervision to make the rural school correlate its work with the high school and college. The boys and girls are worth it and the stimulus for growth and advancement must be placed in the rural school or else the country boys and girls will have less chance in life than their city and village friends.

After all the most valuable products of the farm are the children. Why do the boys and girls leave the farm? Why do they long for the city? Possibly because they think they can have better times there. A "good time" is the goal of many a child's ambition. Then give them such a good time that they will not want to leave. Give more time to their consideration. Make home the most beautiful place on earth to them with flowers and trees, lawn and shrubs about the house. Set aside a place for outdoor games, tennis, baseball, croquet, football and such sports. Let them have a personal interest in it all, give them some place to call their own, to plant if they wish or use as they see fit. Let their gardens be good ground, give help and advice if asked for. Let them have animals as pets and for profit. Many a boy and girl loves his chickens and makes a nice little sum from them during the year. Some may choose to have bees, or pigeons, or rabbits, or lambs, a calf or a colt. The joy of owning such are denied to city children, but the farmers' children should be encouraged to care for them.

Encourage them in their school work, school entertainments, and school contests. Take an interest in the boys' corn contests, potato growing contests and the girls' bread-baking contests. Do not be too busy to attend the school apple show if they have one or to appreciate their showing of vegetables and flowers. Subscribe for some of the best magazines and papers, especially to some devoted to country life. If the child shows a natural inclination toward some particular thing encourage him and develop his talent to the best of your ability.

Just as soon as the boy or girl expresses a desire for a book on any practical or rural subject, get it. If one of the children likes poultry, buy a poultry book. You may need one on birds, or gardening, or trees, or horses, or pets. No child is beyond hope if it likes to read in the sight of father and mother. The child that steals away to read in secret should be looked after. Can you not afford five books in one year on subjects connected with the out-of-doors? Cornell Bulletin No. 28 Farmers' Wives' Reading-Course gives a list of books for children. Since the bulletin was circulated, many have asked for names of five or six good out-of-door books, and the following are suggested as suited to give wholesome reading to the children and interest them in the beauties of country life:

Squirrels and Other Fur-Bearers. John Burroughs. Houghton, Mifflin & Co.	$1 00
Wild Neighbors. Ernest Ingersoll. Macmillan Co.	1 50
Bird Neighbors. Neltje Blanchan. Doubleday, Page & Co.	2 00
First and Second Books of Birds. Olive Thorne Miller. Houghton, Mifflin & Co.	1 60
Field Book of American Wild Flowers. Schuyler Mathews. G. P. Putnam's Sons	1 75
Our Native Trees. Harriet Keeler. Scribner's	2 00

Do not confine the reading to matter of fact. Good stories are always desirable. They cultivate imagination and develop the human interest. Encourage the children to read poems, and to read them aloud. Such poems of childhood as those of Stevenson, Riley, and Field are excellent. If the child once learns to collect and love good books, there is little danger of his turning out bad.

Interest the Child in Your Own Occupation.—One of the perplexing problems of farm life is how to keep young people on the farm. Work needs their attention and consumes their young life and ambition. Too often the larger community holds out to them a more alluring prospect and what to them seem like larger opportunities. It is not always best that a young man or woman should remain on the farm. It may not be according to his taste and ability. But it surely is not always the fact that the bright members of the family are the ones to go abroad into the professions and trades, while those who seem less promising necessarily put the hand to the plow and wear out the days in mere toil. Very many of our best men and women are now on the farms.

Farm life is calling for great intelligence and careful judgment. Its problems are based upon science. The young people who engage in it are much the better prepared for a life's work if they have the training and knowledge now afforded along agricultural lines. With the scarcity of help it too often happens that the young people can not get away from home to secure the training which is for their good and which would lend a very different aspect to farming as a business.

Throughout the country, efforts are being made to afford scientific training for those who are to have charge of the farms. The money invested by the State for the education of the young men and women who are to occupy these farms will add greatly to the wealth and prosperity of the commonwealth. The promotion of agricultural schools is one of the best means of helping the community at large. The hard work and detailed arrangements of farming need perforce to be accompanied by thoughtful care in saving labor and money.

Many boys and girls are turned away from the farm because they hear father and mother say so often that farming is a poor business. The child is made to feel that storekeeping or doctoring, or other occupation, is much better than farming. The farmer's own fireside often sends his children away from the farm. If the farmer does not take pride in his calling, his children will not.

The home, or rather the family, is the most important institution of human society. It is the function of the family in society to conserve all social possessions and hand them down to the next generation; not only are the material possessions thus preserved, but also the spiritual possessions of the race—language, religion, morality, art, government, and ideals. The family not only reproduces the individuals of each generation, but it also reproduces society itself. Moral progress in society rests upon family life. Christianity itself is but an idealization of the family life. The home therefore is by far the most important institution of society.

The children should be taught the sacredness of family life and the importance of a pure and wholesome family life as the foundation of a nation's greatness. They can be taught the sciences and arts upon which a wholesome life rests upon its material side. They should be taught more of the ethical ideals of Jesus concerning the family life. The home itself must teach the young the sacredness of the family. Boys should be taught the same standards of morality as girls, and both should be taught to look upon marriage not as an indulgence, or as simply a means to personal happiness, but rather as a means to a wholesome, unselfish and noble human life.—(Missouri Exp. Sta. Circ. 30; Dept. Agr. F. B. 317; Ky. Sta. Bul. 119; Cornell Read. Course for Farmers' Wives, Series IV, No. 16.)

AGRICULTURAL EDUCATION.

THE FIRST SOCIETIES.

In America the first agricultural efforts necessarily were directed toward clearing the land and growing the crops immediately needed for the sustenance of the settlers and for export to the mother country, whence alone manufactured articles could be obtained. There was little incentive to careful cultivation and scarcely any motive for seeking new knowledge for the improvement of agricultural practice; and to this can be added the general absence of any educational system for the masses, together with the deep-rooted prejudices against book learning as applied to any industrial pursuit, especially agriculture.

The first society for promoting agriculture was established at Philadelphia, then the seat of the General Government, March 1, 1785, by men who were for the most part engaged in pursuits having no immediate connection with agriculture. On the 4th of July, 1785, General Washington was elected an honorary member of this society and ever afterwards showed a deep interest in its proceedings. Benjamin Franklin's name is also found on the list of its honorary members. In the same year a similar society was formed in South Carolina, which had among its objects the establishment of an experimental farm. This society was incorporated December 19, 1795. The present State Agricultural Society of South Carolina still holds the original charter. The New York Society for the Promotion of Agriculture, Arts, and Manufactures was organized February 26, 1791, and about the same time a society was formed at Kennebec, Mass. (now Maine). The Massachusetts Society for Promoting

Agriculture was incorporated March 7, 1792, and in 1794 the Western Society of Middlesex Husbandmen was formed in Massachusetts, though not incorporated until 1803. The Society for Promoting Agriculture in the State of Connecticut was organized August 12, 1794, and published its first volume of transactions, a small quarto pamphlet in 1802. This society still exists as the county society of New Haven.

The formation of agricultural societies was continued and their number rapidly increased. In South Carolina, for example, eleven societies were in existence by 1823. The movement for the establishment of a national board of agriculture was renewed in 1817 by the Berkshire Agricultural Society of Massachusetts, which presented a memorial to Congress on this subject. The bill which resulted from this effort was, however, defeated in the House of Representatives. The following year (1818) saw the establishment of the New York Horticultural Society, the first organization of its kind in the United States.

The first attempt to organize a national agricultural society was made at Washington in 1841 by a convention of persons desiring to elevate the character and standing of the cultivation of the American soil. It was hoped that the fund left by Hugh Smithson might be made available for the maintenance of such an organization, but the establishment of the Smithsonian Institution frustrated these expectations, and the national society remained dormant until 1852.

Early Agricultural Publications.—During this period various methods for diffusing agricultural information were proposed or put in operation, very largely through the efforts of these agricultural societies. Books on agricultural subjects began to appear. Among these, was a volume of over 300 pages, published at Worcester, Mass., in 1790, entitled, The New England Farmer, or Georgical Dictionary: Containing a compendius account of the ways and methods in which the most important art of husbandry, in all its various branches, is or may be practiced to the greatest advantage in this country, by Samuel Deane, A. M., Fellow of the American Academy of Arts and Sciences; and the Rural Socrates, or an account of a celebrated philosophical farmer, lately living in Switzerland and known by the name of Kliyogg.—Hallowell (District of Maine). Printed by Peter Edes, and sold by the booksellers in the principal towns of the United States. A. D. 1800. The author of this book was Dr. Vaughan, a prominent member of the Maine Agricultural Society, who, in 1803-1804, likewise published a series of agricultural papers and essays of much value.

The more important societies soon began the publication of information on agricultural subjects. As early as 1792, the New York society published a small quarto volume of its transactions. In 1797 the trustees of the Massachusetts society began the publication of pamphlets, or, as we now say, bulletins, on agricultural topics, which afterwards were developed into a regularly issued journal. The same year this society established a regular library, having accumulated, by gift and purchase, a considerable number of works on agriculture.

The American Farmer, the first distinctively agricultural periodical in this country, was started in Baltimore in 1819, and was very shortly followed by The Plough Boy, published by Henry Homespun, Jr., at Albany, N. Y. The first agricultural paper in New England was issued in 1822.

Books on agriculture began to come more frequently from the press; among the most characteristic of these were The Farmer's Assistant, by John Nicholson, Esq., published at Albany, N. Y., in 1814 [a second large edition in 1820], embracing every article relating to agriculture, arranged in alphabetical order; Nugæ Georgicæ (Agricultural Trifles), by the Hon. William Johnson, senior vice-president of the Literary and Philosophical Society of Charleston, S. C., published in 1815, which is an endeavor to sketch the outlines of a picture of the cares and amusements, the duties and employments, of the Carolina farmer; Arator, by John Taylor, an eminent statesman and agriculturist, published at Petersburg, Va., in 1818, and considered the forerunner of the American Farmer, which seems to have had a great influence on Virginia agriculture; The Farmers' Library, by Leonard E. Lathrop, published at Rochester, N. Y., 1826-1828, to explain some of the fundamental principles which relate to agricultural science.

The First Fairs.—In 1801 a communication was presented to the trustees of the Massachusetts society which contained the germ of an educational movement on behalf of agriculture, destined to have an important influence on the improvement of the art in this country, especially down to the opening of the civil war. This was the suggestion that fairs should be held in May and October in Cambridge common and small bounties given for certain articles. Nothing was immediately done to carry out this plan; but in 1804, Dr. Thornton, the first United States Commissioner of Patents, proposed that fairs should be held in the city of Washington on market days, after the English fashion. This idea was eagerly taken up by the citizens and municipal authorities, and the first fair was held in October of that year. It was such a decided success that two others were held in succeeding years, after which, however, they were discontinued. A great impetus seems to have been given to this movement by the enthusiastic labors of Elkanah Watson, of Massachusetts, who, beginning with an exhibition of two merino sheep on the public square at Pittsfield in 1807, soon developed the more elaborate and picturesque cattle shows, which for many years were the popular rural festivals, especially in New England. Much interest also attaches to the sheep shearings, the most famous of which was annually held for a dozen years, beginning with 1808, by George Washington Parke Custis, at Arlington, his estate near Washington, on the Virginia bank of the Potomac. This was attended by throngs of prominent men, and had much social as well as agricultural importance. The interest in the movement for the promotion of agriculture awakened at the national capital is further shown by the organization in 1809 of the Columbian Agricultural Society, which was the foundation of the national organization finally formed in 1852. From 1809 to 1812, inclusive, this society held six fairs, at which cattle, woolen goods, cotton cloth, fancy work, clothing, bed linen, sewing thread, carpeting, rugs, dyes, etc., were exhibited.

Early Acts of Congress.—Congress first took an active interest in the promotion of agriculture in 1839, when, on the recommendation of Hon. Henry L. Ellsworth, Commissioner of Patents, an appropriation of $1,000 was made for the collection of agricultural statistics, investigation for promoting agricultural and rural economy, and the procurement of cuttings and seeds for gratuitous distribution among the farmers. This work was gradually developed; investigations in entomology, chemistry, and botany were provided for by 1855, and the way was thus opened for the establishment of the United States Department of Agriculture in 1862.

In February, 1889, the Department of Agriculture was erected into an Executive Department under a Secretary, who is a member of the Cabinet.—(Y. B. 1899 and 1894.)

Farmers' Institutes.—Meetings which the general public and especially farmers were invited to attend were held at a comparatively early day under the auspices of the local or State agricultural societies. Out of these meetings grew a more or less clearly defined institution for the technical education of the adult farmer, now known as the farmers' institute. While the character of the institutes is such as to make it impracticable to assign any definite date as the time of differentiation from other farmers' assemblies, yet the period following the organization of the agricultural colleges under the Morrill Act of 1862 seems to have been the time when the farmers' institutes took a distinct form, and under that name began to receive the patronage of the States. Thus, in 1862 the Massachusetts State Board of Agriculture held a public meeting of four days' duration, and in 1866 the Connecticut State Board of Agriculture held its first farmers' convention for lectures and discussion. In 1870 the newly organized State Board of Agriculture of New Hampshire began a series of farmers' meetings, and the following year Vermont followed this example. The same year the Massachusetts board requested the twenty-nine agricultural societies of the State to organize annual meetings, to be denominated the Farmers' Institutes of Massachusetts, and several societies began at once to hold such meetings. About the same time institutes were inaugurated in Kansas, and a little later in Michigan, by the agricultural colleges of these States. Other States joined the movement, and legislatures began to make appropriations to maintain the institutes.

In 1885, when the board of regents of the University of Wisconsin organized a course of institutes, a special officer, called the superintendent of farmers' institutes, was appointed to plan and manage them, and this arrangement was afterwards confirmed by the State. While the institutes are carried on under varied auspices in the different sections of the country, the character of the meetings themselves has been essentially the same wherever they have been held. They are usually held during the winter months, but in some cases at other seasons of the year, and as a rule continue from two to four days. The programmes are planned to promote the interchange of ideas, a full and free discussion being sought upon topics introduced in an address or paper by some specialist. Officers of agricultural colleges and experiment stations, and other experts, together with successful farmers who have attained more than local reputations, are usually selected as institute workers by the officers who have charge of the system of institutes for the State, or they may be chosen by the local authorities from lists prepared by the central bureau. There is very often a local committee, which provides local speakers, music, literary, and other general exercises, and arranges for the place of meeting, refreshments, and advertising.

All persons in attendance, the humblest as well as the most prominent, are urged to ask questions upon points suggested in the address and to present related facts gained from personal experience. A question box is frequently made use of, answers being given by the conductor of the institute or by some one specially fitted to supply the information asked. For the evening sessions the usual plan is to have a popular lecture upon some subject of general agricultural interest. This address is made somewhat more elaborate and complete than those of the day sessions and less opportunity is given for discussions.—(Y. B. 1899.)

In 1910 the total number of regular institutes held was 5,651. There were 16,586 sessions, lasting 7,935 days, with a total attendance of 2,935,908. The aggregate appropriations for these sessions were $432,374.25. These figures are significant as compared with those of 1899, when about 2,000 regular institutes were held, having an attendance of over half a million farmers, the total appropriations for which amounted to slightly more than $170,000. In the total attendance for 1910 there was a slight decrease from that of 1909.—(Y. B. 1901; A. R. E. S. 1910.)

An examination of the cost per session for the year ended June 30, 1910, shows a variation of 367 per cent between the lowest and highest, and from 6½ cents per individual present at these sessions to 62 cents per individual. Sixteen States expended an average of $40.43 for each institute session. These States represent a total expenditure of $183,175.06, and held 4,529 sessions. Twelve States expended on an average $26.22 per session, representing a total expenditure of $112,883.38, and 4.304 sessions held. Eighteen States expended an average of $15.38 per session, representing 7,753 sessions held and a total expenditure of $119,287.85. One State expended on an average $4.30 per session; another $8.45; and another $8.59.

If the entire institute system of the country could be run upon the amount per session, $15.38, expended by 18 States, there could be added without increased cost to the country 10,029 sessions of institutes to the present number of 16,586, or over 60 per cent.

These facts show that there is manifestly need for careful study on the part of many institute directors of the practice in other States with a view to the more economic use of their institute appropriations and the better utilization of their institute force.

The weakest point in the farmers' institute at present is in its failure to see that its teaching on the platform is put into practice. Valuable information is given at an institute meeting. At its close the whole matter is dropped for a year, possibly never to be again referred to. There is failure to follow up by personal effort what has been recommended and to make sure that the teaching of the institute is not lost and that the money of the State expended at that meeting has not been wasted.

Giving instruction is only a part of the duty of the institute. Getting information into the practice of the people is the main purpose for which the farmers' institute is organized. After the information has been given the chief work of the institute begins. If the teaching has been the growing of fruit, then in all communities where this has been advised some one should be located to see that at least a few of those who were instructed take up the work and carry it on according to the method proposed. If, as at present, this is left to individual initiative, it may or it may not be done and often, even if undertaken, may fail for lack of proper and timely expert attention and advice. More time and more money should be spent after the lecture in getting it applied than in its preparation and delivery.—(A. R. E. S. 1910.)

Speaking along this line in an address before the members of the Farmers' Institute of the Province of Ontario, Canada, Mr. G. A. Putnam, Superintendent of the Institute, remarked as follows: We have heard it stated for the past twenty years that the Institutes were no good, that they were not doing the work which they should do, that they did not reach the number of farmers that they should reach, that they did not get hold of the farmers who are most in need of the instruction which the Institute was intended to give. That has been the history of Institute work in all countries. We recognize that the Institute is not getting hold of the people as it should, and we recognize that it never has gotten hold of them as it should, or, to put it in another way, all persons who have been connected with institute work have been discouraged in many cases because they could not induce the people whom they were seeking to benefit to take that personal interest in the work which its importance demands. You will note from our annual report that there is a slight falling off in attendance. Our membership is considerably above last year, and I do not think we should be discouraged after looking at the statistics as a whole; but I know that some of you are discouraged, and I know that I am discouraged in comparing the work in some districts with the work that has been done in former years. We must remember, however, that conditions are somewhat different. In the first place, farmers have much better agricultural journals than they had some years ago, and are well satisfied with that literature, and then they get much literature

School Wagons Returning Pupils to Their Homes. Dept. of Agr.

Semi-Tropical Army-Worm; Late Irish Potatoes Stripped of Leaves.
Dept. of Agr.

from the Department, and they are anxious to get it and make good use of it; but some do not attend the meetings with the same readiness that they did before. You all know that the labor problem is a very serious one, and the farmer and his wife have not now the same freedom in getting to meetings that they had some years ago.—(Report of the F. I. 1910, Province of Toronto.)

Agricultural Colleges.—In 1819 Simeon De Witt, surveyor-general of New York, published a pamphlet at Albany urging the foundation under State authority of the Agricultural College of the State of New York, not so much to give instruction to farmers as to make farmers from the other classes of society, which are stocked with such a superfluity of members that hordes of them must otherwise remain useless or worse than useless to the community. Two years later (1821) Robert Hallowell Gardiner, of Maine, obtained an annual grant of $1,000 from the State legislature to aid in maintaining an institution which was to give mechanics and farmers such a scientific education as would enable them to become skilled in their professions. This institution was incorporated as the Gardiner Lyceum; a stone building was erected for its use, and students were first received January 1, 1823.

In 1825 a plan for an agricultural college was submitted to the legislature of Massachusetts and discussed there and in the New England Farmer and other papers for some time. It was to be much like other colleges of the time, with the addition of courses in agriculture and mechanic arts, provided with a farm and shops. No immediate results followed this agitation. An agricultural school established at Derby, Conn., in 1826, proved immediately successful, and was obliged to increase its accommodations for students.

Agitation on behalf of agricultural education grew more active, and between 1845 and 1850 a number of agricultural schools were established by private enterprise in New York and Connecticut, some of which met with considerable success for quite a period. In 1846 John P. Norton was appointed professor of agricultural chemistry and vegetable and animal physiology at Yale College, and the demand for teachers of agricultural chemistry had grown to be sufficient by 1848 to warrant the establishment of a course for their preparation at the same institution. In 1853 the New York legislature passed acts establishing a State agricultural college and an industrial school, to be known as The Peoples' College. These institutions, however, did not become firmly established. Agricultural colleges which have grown to be permanent and strong institutions were opened for students in Michigan in 1857 and in Pennsylvania and Maryland in 1859.

State agricultural colleges were incorporated in Iowa and Minnesota in 1858, and professorships of agriculture were established about this time in several literary colleges.

On December 14, 1857, Mr. Morrill of Vermont introduced into the House of Representatives a bill donating public lands to the several States and Territories which may provide colleges for the benefit of agriculture and mechanic arts, and granting 20,000 acres of land for each Member of Congress for this purpose. In the next session of Congress the bill passed both Houses, but was vetoed by President Buchanan. Mr. Morrill persisted in his efforts to secure national aid for industrial education, and on December 16, 1861, introduced an amended bill. A similar measure was introduced in the Senate May 2, 1862, by Benjamin Wade, of Ohio. On May 28 the bill was reported adversely in the House by the Committee on Public Lands, but was passed by the Senate June 10, and nine days later by the House. President Lincoln approved the bill July 2, 1862.

The amended bill bestowed 30,000 acres of land for each member of Congress upon the several States for the establishment of colleges to teach such branches of learning as are related to agriculture and the mechanic arts, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life.

In 1890 Mr. Morrill succeeded in having Congress pass a second bill designed to aid industrial education. It was signed by President Harrison, August 30, 1890. This second Morrill act provided that there should be annually appropriated to each State and Territory, out of the funds arising from the sale of public lands, for the more complete endowment and maintenance of colleges for the benefit of agriculture and the mechanic arts established under the act of 1862, the sum of $15,000 for the year ending June 30, 1890, and an annual increase of the amount of such appropriation for ten years thereafter by an additional sum of $1,000 over the preceding year, and that then the amount shall continue at $25,000. This money can be applied only to instruction in agriculture, the mechanic arts, the English language, and the various branches of mathematical, physical, natural, and economic science, with special reference to their applications in the industries of life, and to the facilities for such instruction.—(Y. B. 1899 and 1894.)

There are now in the United States 67 agricultural colleges, organized under the acts of Congress of July 2, 1862, August 30, 1890, and March 4, 1907, giving Government aid to colleges for the benefit of agriculture and the mechanic arts. In 16 States separate institutions are maintained for white and colored students, and in 15 of these courses in agriculture are maintained. The colleges of agriculture may be divided into three classes, determined by differences in their organization: (1) Colleges offering only agricultural courses; (2) colleges offering additional courses, especially those in mechanic arts; and (3) colleges of agriculture connected with universities.

The only purely agricultural college in the United States is that in Massachusetts. Agricultural and mechanical colleges are maintained in Alabama, Colorado, Connecticut, Delaware, Hawaii, Iowa, Kansas, Maryland, Michigan, Mississippi, Montana, New Hampshire, New Jersey, New Mexico, North Carolina, North Dakota, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Texas, Utah, Virginia, and Washington. Separate institutions of this class for colored students (including departments of universities located apart from the other colleges of those universities) are maintained in all of the southern States.

The state appropriations for the maintenance of agricultural colleges, the construction of buildings, and the purchase of equipment are growing larger year by year. Several of the biennial state appropriations for these institutions have approached or passed the half-million mark, notably in Washington, $487,256; Pennsylvania, $526,000, and Kansas, $671,500. There were other large appropriations for the colleges, among which may be mentioned $64,900 for the Arkansas University and Station; $119,000 for the Colorado College and Station; $105,000 for the Georgia College; $165,300 for the Montana College and Station; $202,100 for the Utah College and Station, and $175,000 for the New York College of Agriculture for one year. The legislature of Tennessee has passed a bill giving 25 per cent of the State's revenue for education.—(Ex. S. Circ. 106, 1911.)

Experiment Stations.—The society organized in South Carolina in 1785 had among its objects the establishment of an experiment farm. President Washington, who was a member of the first society for promoting agriculture organized in the United States, in pleading for the establishment of a national board of agriculture in his annual message to Congress in 1796, says that one of the functions of such a board is "to encourage and assist a spirit of discovery and improvement by stimulating to enterprise and experiment."

In 1849 the New York Agricultural Society established at Albany a chemical laboratory for the analysis of soils, manures, etc., and an elaborate examination of maize was made there by Dr. Salisbury. In 1855 a special agent was employed by the Patent Office to investigate and report upon the habits of insects injurious and beneficial to vegetation, especially those infesting the cotton plant. After the establishment of the Department of Agriculture in 1862, as a branch of the Government distinct from the Patent Office, the land on which its buildings now stand was for several years chiefly used as an experiment farm.

The act establishing an agricultural college which was passed by the legislature of Maryland in 1856 made it a duty of the board of trustees of the institution to conduct on the college farm a series of experiments upon the cultivation of cereal and other plants adapted to the latitude and climate of the State.

In 1870 a school of agriculure and horticulture was established in connection with Harvard College in accordance with the provisions of the will of Mr. Benjamin Bussey, of Roxbury, Mass. This school was named the Bussey Institution. The same year Harvard College received from the Massachusetts Society for Promoting Agriculture a considerable sum for the support of a laboratory and for experiments in agricultural chemistry to be conducted on the Bussey estate. Investigations were begun in this laboratory, in 1871 by F. H. Storer, the professor of agricultural chemistry in the Bussey Institution, and his assistants, and the first report of their work was made December 3, 1871. The earliest experiments consisted of field tests of fertilizers upon the farm of the institution and chemical analyses of commercial fertilizers. A number of bulletins were published, including reports of field experiments and investigations on hybridizing plants, the composition of feeding stuffs and fertilizers, injurious fungi, and physiology.

When the College of Agriculture of the University of California was organized it was understood that a part of its work would consist of experimental inquiries. In 1870 Prof. E. S. Carr, in an address at the State Fair, stated that the University proposes to furnish the facilities for all needful experiments; to be the station where tests can be made of whatever claims attention.

After the fund which had been established by the sale of the land scrip donated to Connecticut under the act of Congress of July 2, 1862, had been given to the Sheffield Scientific School of Yale College, in 1863, a professor of agriculture was added to the working force of that institution. It is doubtless safe to say that through the influence of the professors and pupils trained in this school, more than to any other single cause, is due the recognition of the importance of the establishment of agricultural experiment stations, first in Connecticut and subsequently throughout the whole country.

On December 17, 1873, at Meriden, Conn., at a meeting of the State Board of Agriculture, the establishment of an Agricultural Experiment Station was urged. A petition to the legislature for this purpose failed. Upon a contribution of $1,000 from Mr. Orange Judd and an offer of the free use of its chemical laboratory by Wesleyan University, the legislature reconsidered its decision and appropriated $2,800 per annum for two years for the work of the Station. Thus was established in 1875 the first State Agricultural Experiment Station in America.

The success which attended this first attempt was sufficient to attract the attention of advanced agriculturists throughout the country, and the example set by Connecticut was soon followed in other States. March 12, 1877, the State of North Carolina established an agricultural experiment and fertilizer control station at Chapel Hill in connection with the State University. The Cornell University Experiment Station was organized in February, 1879, by the faculty of agriculture of the university, as a voluntary organization. The New Jersey State Experiment Station at New Brunswick, N. J., was established March 18, 1880, by an act of the State legislature and connected with the scientific school of Rutgers College.

The experiment station enterprise was called to the attention of the House of Representatives in 1886 by a bill which was introduced by William H. Hatch, of Missouri, and referred to the Committee on Agriculture. This committee made a favorable report March 3, 1886, and nearly a year later the bill was passed by Congress, and was approved by the President March 2, 1887. The

Hatch Act provided that $15,000 a year shall be given out of the funds proceeding from the sale of public lands to each State and Territory for the establishment of an agricultural experiment station, which must be a department of the land-grant college, except in the case of those States which had established experiment stations as separate institutions prior to the passage of the act.—(Y. B. 1899.)

The growth of the stations as regards their number and resources is shown by the following general statistics for the earlier years of their operation under the Hatch Act (1887), as compared with those for the year 1910. In 1888 there were 46 stations in 38 States and one Territory with an aggregate income of $720,000; in 1910 62 stations in every State and Territory reported a total revenue of over $3,000,000.—(Y. B. 1899, 1910.)

In general the work of the agricultural experiment stations, as organized in this country, may be classified as follows: (1) They act as bureaus of information on many questions of practical interest to the farmers of their several localities; (2) they seek by practical tests to devise better methods of agriculture and to introduce new crops and live stock, or to establish new agricultural industries; (3) they aid the farmer in his contest with insects and with diseases of his crops and live stock; (4) they help to defend the farmer against fraud in the sale of fertilizers, seeds, and feeding stuffs; (5) they investigate the operations of nature in the air, water, soil, plants, and animals in order to find out the principles which can be applied to the betterment of the processes and products of agriculture.—(Y. B. 1894.)

These forces devoted to agricultural education and investigation should be utilized to the utmost by our farmers to the end that their sons and daughters may be educated to a better citizenship and higher efficiency; that farm practice may be improved; that new and important phases of agriculture be developed. This means not only profit and benefit to the individual, but prosperity and advancement for the State which has generously recognized the importance of fostering the farming industry by establishing and aiding the work here described.—(Purdue Univ. Bul. 107.)

The experiment station enterprise in this country has in it the potency of a vast influence of the greatest of the industries; it is to be an important permanent feature of the system of institutions for education and research.—(Ex. S. Circ. 30.)

The Experimental Union opens up a channel through which some of the best material of the Experiment Station can be brought to the homes of the farmers. It makes direct application of the information gained at the college by having experiments conducted on hundreds and even thousands of farms, and it systematizes the co-operative work in such a way that the results of those experiments which have been conducted with care and accuracy can be summarized and made into valuable reports for the guidance of farmers generally. It introduces improved methods of farming along various lines. It combines, in an admirable way, the training of the hands and the training of the intellect. It is therefore not only a source of practical gain in dollars and cents to the farmers, but it is a great educational feature which has had a very wholesome influence, not only on the agriculture of the Province, but also on the agriculturists themselves.—(Ex. Univ. Ontario, Can.)

Secondary Education.—It was fully 30 years after the first State Agricultural College was opened in this country before the first successful agricultural high school was established in connection with the College of Agriculture of the University of Minnesota but the success of that school was so pronounced that within 22 years at least 80 agricultural high schools of different types have been established and, together with 29 public high schools, are receiving State aid for agriculture, while no less than 24 privately endowed colleges and schools are giving instruction in agriculture. Furthermore, over 150 State and county normal schools are preparing young people to teach agriculture, and over 400 public and private high schools and academies are giving some instruction in agriculture.

The Minnesota School of Agriculture was established in 1888. Similar schools of agriculture or two-year or three-year preparatory or practical courses intended to serve the same purpose of training young men for the farm without insisting that they first complete a large amount of work in language, mathematics, and the primary sciences, are now maintained in connection with the colleges of agriculture in Alabama, California, Colorado, Connecticut, Florida, Idaho, Louisiana, Maine, Maryland, Minnesota, Montana, Nebraska, Nevada, New Hampshire, New Mexico, North Dakota, Oklahoma, Oregon, Rhode Island, South Dakota, Virginia, Washington, and West Virginia.

Of the separate agricultural high schools receiving State aid there are several types, chief among which may be mentioned the congressional district agricultural high schools and the county agricultural high schools. Alabama was the first State to establish an agricultural school in each congressional district. Each school has a branch experiment station connected with it, is provided with land for experimental and instructional purposes, receives $4,500 annually from the State for maintenance, and has an equipment of buildings, animals, and machinery more or less complete. The course of study in each school extends over four years and corresponds in grade to that of other high schools in the State. Usually these schools are connected with local public schools and resident pupils predominate, but there are also quite a number of pupils enrolled from the towns adjoining each school. Georgia has 11 congressional district agricultural schools.

County agricultural high schools which are now in operation in a number of States were first established in Wisconsin in 1902. These schools have been equipped at the expense of the counties where they are located, but the State aids each school to the extent of $4,000 a year to be applied to the running expenses. The course of study in each school extends over two years, and the work includes soils, plants, animal husbandry, dairying, rural architecture, blacksmithing, carpentry, and mechanical drawing, for boys; and cooking, laundering, sewing, millinery, floriculture, household bacteriology and physics, home nursing, and home management and decoration, for girls, besides English, United States history, civil government, and commercial arithmetic for both boys and girls. Tuition is free.—(Ex. S. Circ. 106.)

Some ways in which these schools help the farmer are as follows: Prepare plans for farm buildings; make suggestions for remodeling old buildings; build forms for and supervise the construction of cement silos, water troughs, and similar structures; test all kinds of dairy products; assist in the selecting of farm animals; plan drainage systems; test farm seeds for germination; test cattle for tuberculosis; test soils and recommend systems of rotation.—(Ex. S. Bul. 42.)

From a recent compilation of data concerning the status of secondary agricultural instruction in the United States at the close of the year ended June 30, 1909, it appears that there were 60 agricultural high schools or definitely secondary agricultural courses in colleges, between 300 and 400 public high schools and academies teaching agriculture, 109 state or county normal schools, and 16 agricultural colleges training young men and women to teach the more elementary phases of agriculture, and quite a number of private colleges and schools giving instruction in agriculture of secondary grade or correspondence courses which are approximately of secondary grade, making in all about 500 institutions giving secondary instruction in agriculture.—(A. R. E. S. 1909.)

Normal Schools.—The particular work of the normal school is to prepare young people to teach school. Whatever else it may do can not be considered normal school work.—(E. S. Cir. 90.)

The normal schools all over the country are responding as rapidly as their resources will permit to the demands made upon them for teachers having some knowledge of the principles of agriculture. Among the more recent legislative acts bearing on this phase of the educational movement is that of the legislature of Texas, which at its last session appropriated $2,000 a year for two years to each of its three state normal schools, for the purpose of installing, equipping, and maintaining departments of agriculture, manual training, and domestic science. The act also made provision for the introduction of teachers' courses in elementary agriculture in the summer sessions of these three normal schools. For the support of this work $3,000 annually was appropriated to be divided equally among the six institutions.

The normal and industrial schools for girls at Rock Hill, S. C.; Milledgeville, Ga.; Montevallo, Ala.; Columbus, Miss.; and Denton, Tex., are among the institutions which now have definite departments of agriculture and provide courses of instruction in this subject for the young women who attend their classes.

The normal schools of Illinois during the past year have come into closer touch with the interests of their farming constituency by holding a number of farmers' institutes at the schools. An association of country teachers was formed at a meeting held at the Macomb Normal School, to be known as the Country Teachers' Association of Illinois, and having as its main purpose to increase the usefulness of the country school by improving its physical and social environment and enriching its course of study in such a manner as will bring the child into sympathetic and vital relationship with his environment, by country school extension work through the different educational institutions, offices, and agricultural associations, by consolidating weak country schools, by encouraging more thorough preparation, larger salaries, and longer tenure of positions for teachers, and by the further development in state normal schools of facilities for training country school teachers. A similar association of agricultural school teachers has been formed in Wisconsin, and another in Nebraska.—(A. R. Ex. S. 1909.)

Elementary Education.—The agricultural work which is now being attempted in the public schools in different parts of the country includes not only instruction by means of textbooks, of which there are now a considerable number, but also several different phases of practice work or special instruction, among which are the following:

(1) Nature study with plants, farm crops, domestic animals, and soils.

(2) School-garden work, including the growing of flowers, vines, and shrubbery for the improvement of school and home grounds and of vegetables in gardens at the schools or at home.

(3) Lecture courses and institutes for rural school children.

(4) The organization of clubs among rural school children to encourage the boys to undertake simple experiments with fertilizers and field crops, and the girls to engage in some kind of domestic-science work.

(5) Boys' rural encampments, in which regular camp duties are interspersed with athletics and other amusements, lectures, instruction in agriculture, and practice in judging farm crops and live stock.—(Ex. S. Circ. 106.)

The fundamental difficulty with agricultural conditions is that there is no attempt to instruct the children in matters which will awaken an interest in country life. Therefore the place in which to begin to correct the agricultural status is with the children and the rural schools. Hence the greatest good which can be rendered to the agricultural communities is to awaken an interest in nature-study on the part of teachers and children.—(Cornell Univ. Bul. 137.)

Teachers of nature-study, when located in city schools, have brought to the consideration of their classes the trees, shrubs, flowers, and vines found around the city homes, in the parks, and in the lawns, and have studied the insects, birds, and other animal life of the city in relation to this plant life. In the country they have considered the plants, animals, birds, and insects which surround the farmer and aid or hinder him in his work, giving much attention to their economic importance and very little to any marked peculiarities they might chance to possess. Such nature study forms an excellent basis for the subsequent study of more formal agriculture.—(Ex. S. Circ. 60.)

While there are many ways in which a teacher may help the country scholar, yet it would seem that the most practical means yet adopted is through the school garden. This can be carried out on a smaller or larger scale anywhere. It opens up a new field of thought each week as growth progresses; it suggests problems in plant life and the production of foodstuffs; it gives variety of work during school hours; and it suggests farm problems which have already been solved and the solutions published by the college authorities. The reports and bulletins containing such information can then be intelligently discussed with the pupil and the parents, and in this way the work of the school can be brought in closer touch with the work of the farm.—(Ontario A. C. Bul. 29.)

The growth of sentiment in favor of teaching the principles of agriculture in the elementary schools has been rapid in recent years. There are now 13 States in which the teaching of agriculture in the rural common schools is required by law. It is encouraged by State and county school officers, and taught in some of the rural schools of 31 other States. In all, 44 States and outlying possessions are making some effort to teach the underlying principles of agriculture in the rural common schools.—(Ex. S. Circ. 106.)

The courses of study in our schools have had a tendency to give the boys a liking for city life, and have bred in them the ambition to leave the quiet and industry of the farm for the noise and rush of the city. To the lay mind the remedies seem plain. Remodel the courses in the rural schools, give the boys more physical training, have the schools teach the beauty of nature, give to the young mind an understanding of the different forms of life with which he is surrounded. Have the school gardens started as object lessons, and in a general way have all study tend to give a fondness for rural life. Coupled with these different studies the best literature should be taught so that the mature mind would have a liking for reading and communion with the great minds of all time. But you will say how are these remedies to be applied? In the first instance, the rural public and the public generally must be educated to spend more money on education. The recent changes and increased grants by the Department of Education seem to have been approved by the public, and what is now needed is the intimation from the people that more should be done and the government will readily take action.—(A. R. Ex. Univ. Ontario, Can.)

In conclusion, it must be said that the farmers, as a whole, are willing and anxious for education. They are difficult to reach because they have not been well taught, not because they are unwilling to learn.—(Cornell Univ. Bul. 137.)

Boys' Corn Clubs.—The boys' demonstration work teaches the boy how to make a crop successfully and economically; hence, there is an element of economic management and profit in it. It inspires a love of the soil, and above all when the boy is successful there is a consciousness of achievement, which is of great value. It is not merely a boys' club for the purpose of having a set of rules or an organization. True, this idea is used, but mainly in an incidental way. This work is not a contest in corn growing, wherein each one who enters is left to prepare, plant, fertilize, and cultivate in his own way. Of course, prizes are offered in the work, but for the purpose of arousing interest and keeping up enthusiasm. The plan is to instruct, to direct, to guide, and to train. The circulars of instruction sent at different times throughout the year cover the fundamental principles of good farming, such as deep fall plowing, the pulverization of the soil, seed selection, suitable spacing, intensive cultivation, the increase of humus, and the economical use of fertilizers, the systematic rotation of crops, the use of more horsepower and better implements, and the keeping of farm accounts. The effort is made to have each boy receive attention and instruction on his acre or the acre of a neighboring boy. A boy takes pride in ownership and will learn more agriculture and more business on his own acre of corn than elsewhere.—(B. P. I. Bul. 41.)

Institutes for Women.—In making the country home a special department in institute organization and effort, through the organizing in rural districts of societies composed altogether of women, the paramount importance of woman's work as the home builder is recognized by the State, and systematic effort made to aid her from the public treasury.

The relation that women sustain to the rural schools as teachers of the youth of the country is most important, and furnishes a potent reason why they should have special training for rural-school work. They are by great majority the instructors not only in the rural schools, but in the town and city schools as well, and the future nation consequently will depend very largely for its efficiency upon the manner in which these teachers perform their work.

The object of the women's institute is to do for the woman in the home what the institute is endeavoring to do for the man in the field, namely, increase the efficiency of the individual and cause her to take new and more intelligent interest in her occupation. The women's institute, therefore, should endeavor to reach every country home with a school of domestic and sanitary science and household art; should strive to introduce labor-saving appliances and conveniences into every home; should endeavor to bring about conditions whereby leisure and opportunity for social enjoyment and self-improvement can be secured by every rural family, and whereby good literature, music, and artistic skill may be introduced into and enjoyed in every country home, and the latent talents of country women, intellectual, social, and religious, be developed and employed.

That this work is coming into appreciation is shown by the fact that 16 States held 444 institutes for women in 1909, or 299 more than were held during the previous year. Before, however, they will increase with the rapidity that their importance demands it will be necessary for the State directors to send out organizers to call meetings for women and organize them into clubs as auxiliaries to the farmers' institutes of the county and State. If this were done their number would increase many hundredfold within a year. As soon as the State directors come to see and appreciate the importance of this phase of their work such organizers will be employed and women's institutes established equal in number at least with those now in operation for men.—(Ex. S. Circ. 85; A. R. Ex. S. 1910.)

"University Extension" Work.—The term university extension has been used in recent years to denominate in a general way the efforts of our colleges to promote the diffusion of knowledge outside of their own halls. Though not always spoken of under this head, no university extension movement in this country has actually been so widespread as that on behalf of agriculture. Broadly speaking, this would properly include the dissemination of agricultural information through the publications of the experiment stations and this Department. The stations annually issue over 400 publications, which are distributed to mailing lists aggregating half a million addresses, and this Department supplements these with some 600 others, of which about 7,000,000 copies are distributed. But confining ourselves to what would more usually be considered university extension work, we find the colleges of agriculture largely engaged in conducting farmers' institutes and home-reading courses and helping to introduce nature study into the common schools. The result of pushing this educational motive into the rural communities has been a most decided waking up of those communities, which, even if the work were to stop at the present time, will continue to exert an influence for a generation and more.—(Y. B. 1899 and 1897.)

The development of agricultural extension by the land-grant colleges has been one of the most remarkable features of their work during the year. The report of the standing committee on extension work of the Association of Agricultural Colleges and Experiment Stations shows that extension departments have been organized in 32 States and Territories by 35 institutions, and that in 3 other States departments have been partially organized. One hundred and thirteen persons were employed for their full time in extension work in connection with the colleges and stations and 189 persons contributed part of their time. Appropriations from all sources for carrying on the work during the year amounted to something over four hundred thousand dollars.—(A. R. Ex. S. 1910.)

Education extension in agriculture has suddenly come into such prominence as to demand much attention from those who have the needs of agriculture to provide for. This new movement requires that the interests of agricultural people shall be considered with reference to providing facilities for instruction in agriculture, not merely for the comparatively few students resident in colleges, but also for the great body of rural people who are unable to attend distant agricultural institutions or even to enter upon a normal or high school course.—(A. R. Ex. S. 1909.)

Fair Associations.—A recent investigation by the institute specialist into the condition of the county fair associations shows that there are over 1,200 of these societies in the United States with a registered membership of approximately 250,000. Their gross receipts for the year 1909 amounted to about $6,500,000 and their expenditures for premiums to about $2,500,000. These societies are incorporated under the laws of their respective States and so have continuous existence and in many cases have an assured income for their support. That they have not been utilized by agricultural educators in the past as they should is quite evident to those who have studied their capabilities.

A strong, local organization is needed in every county to form a center to which rural people in the country can look for information and assistance in carrying on their work. The agricultural colleges also, now that they are undertaking extension work in agriculture, need an organized body of men in each county to act as their agents in disseminating information and for attending to local matters that require the presence of some one on the ground familiar with local conditions. The State departments of agriculture, likewise, are interested in having a representative in each county as a correspondent to gather information and to report periodically the condition of the crops, the state of the markets, the presence of contagious diseases among animals, of injurious insect pests, or fungus diseases among plants. In these and many other directions a fair association can be useful to the community in which it is located and to the country at large. The agricultural colleges are already using these societies for making known their work and for disseminating information useful to farming people.—(A. R. Ex. Sta. 1910.)

The opportunities presented and the advantages offered by the county fairs are manifold. They afford opportunity to meet the farmers personally and explain the work of the institution; to secure co-operators in demonstration work; and to initiate new movements for the improvement of agriculture. In addition, they permit the colleges to conduct agricultural schools and short courses and demonstrations while the exhibition is in progress; they educate the fair managers in the conduct of agricultural exhibitions; they provide a place for the exhibition of the results of contest work by the school children and country youth; and they enable the college and station to secure names and addresses of representative farmers and of young people with whom to correspond in disseminating agricultural information, and in securing co-operation in projects for rural development.—(Ex. Sta. Cir. 109.)

Agricultural Libraries.—To furnish the right book to the right man at the right time is a problem that faces every student of agricultural affairs who would help men to better ways of farming. The need of offering the book at the right time presents a new opportunity for the agricultural library.

The production of fit books for the advancement of agriculture has long engaged the attention of promoters of scientific farming, but it is only during the last century that these books, or the information in them, have been supplied directly to the farmer. Furthermore, this supply has been thus far chiefly by books singly at home, and through the agricultural papers; and because the newspaper and the single book can not cover the whole great field of agriculture, the farmer has constantly found himself wanting information on one subject and his book or his paper offering him information on another. When cholera suddenly breaks out among his hogs, his paper has an article on sheep scab and his book deals with the diseases of the horse. His need is a library within reach that will furnish in concise form the entire body of thoroughly proved agricultural science. (The principal object of this series of books entitled "Abridged Agricultural Records," is to provide the farmer and his family with correct information on all farming operations; the indexes will enable him to make instant use of every line.)

Libraries have multiplied and have grown in numbers of volumes and in activity wonderfully during the past twenty-five years, and of late they have begun to come to the farmer. Granges, farmers' clubs, farmers' institutes, and farmers' reading circles have all helped to create a demand for books, and to some extent have helped to meet it. During the past ten years the traveling library movement has developed. As a result many small libraries are sent out to rural communities and are constantly exchanged among them. But these libraries are made up chiefly of light reading, and even such as are agricultural can not be depended on to meet cases of urgent demand, because they are at one place only a few months. The establishment of permanent libraries of standard agricultural works near the farm home is a suggested need. In this direction seems to lie another step, both in library development and in the progress of scientific farming.—(Y. B. 1899).

The founding of agricultural libraries in this country was first undertaken by the agricultural societies established in several of the states just after the close of the Revolutionary War. In those early days agricultural books were no more numerous in general libraries than at the colleges, and were probably not as much used.

Agricultural libraries have now been established in connection with the agricultural colleges and experiment stations in every State and Territory in the Union. In addition to their use by students in the colleges and stations, most of these libraries are free to all who are likely to be helped. In States in which the agricultural college and the experiment station are separated there are two such libraries, one at the college and one at the station. In majority of them the shelves are open to all readers. Farmers are especially welcome.

The traveling library movement originated in 1892 by Melvil Dewey, librarian of the New York State Library at Albany, has from the start been an especial boon to rural communities, and an effort has usually been made by the organizers in the various States where the system exists to encourage farmers to read books on farming and domestic science. But in some of the early libraries sent out to farm neighborhoods in Wisconsin, and probably in other States, there was not a single book dealing with agricultural topics. The reason was that the managers of the work believed the books must be entertaining and attractive, and this opinion was founded on experience. Now, however, in several States it is made a point to send at least one book on agriculture with every library, and many traveling libraries are made up entirely of works on farming, horticulture, and home making and keeping.

Government Publications.—The educational advantages of government publications (as shown in the "Abridged Agricultural Records" and otherwise) may be set forth as follows: The farmer learns from them: (1) What the Department of Agriculture at Washington knows from its vast stores of information about the special crop under consideration; (2) what the state agricultural experiment stations have demonstrated to be the most advantageous methods; (3) what the best farmers have tested and proved to be the most successful practices upon the farms; and (4) the knowledge obtained by the traveling agents of demonstration work, who visit and have personal knowledge of the localities in the State in which they are stationed.—(F. B. 422.)

Short and Special Courses.—The agricultural colleges have sought to meet the demand for more elementary and practical education in agriculture by establishing short courses. These may either cover agriculture in general or be confined to some special line, as dairying. The courses offered by the University of Wisconsin may serve to illustrate this feature of the American system for agricultural education. The short course in agriculture, it is stated, is designed to meet the wants of young farmers who desire practical, helpful instruction in agriculture before taking up their chosen vocation. This course covers two terms of twelve weeks, each, beginning the first of January each year. It includes lectures on feeds and feeding, breeds of live stock, agricultural chemistry, agricultural physics and meteorology, plant life, veterinary science, dairying, farm bookkeeping, horticulture, agricultural economics, and bacteriology. Laboratory practice is given in dairying, physics, plant life, stock judging, and horticulture, and practical work in carpentry and blacksmithing. The dairy course occupies one term and includes theoretical and practical instruction in the science and practice of dairying and dairy farming. It is definitely planned to meet the needs of persons intending to operate creameries and cheese factories, and has been very successful in training men competent for work of this kind. The students engage in milk testing, operate separators and butter extractors, and attend to the ripening of the cream, churning and packing butter, and all the operations of a creamery and cheese factory.—(Y. B. 1897.)

Home Reading Courses.—Various plans for extending the influence of the agricultural colleges among the farmers by what is known as university extension work have been tried during the past five or six years. One of the most interesting of these movements was inaugurated by the State College of Pennsylvania. In 1892 this college offered a course designated as Home Reading in Agriculture, the main features of which were as follows:

(1) A carefully prepared course of reading designed to cover the most important branches of agricultural science and practice.

(2) A reduction of price upon the books needed, all of which were standard works.

(3) Personal advice and assistance through correspondence.

(4) Examinations upon subjects read, with certificates and diplomas for those attaining certain grades of excellence.

This course attracted considerable attention at home and abroad and received numerous applications for admission from students, a number of whom did excellent work, completed their prescribed course, and received diplomas. The course consists of thorough study of ten books and a satisfactory examination upon the same.

To meet the demand made by the students for greater aid from the college, lessons have been provided on various books in the course. These are sent to students free of cost. These lessons aim to give new matter, or, in other words, to bring the book up to date, to make suggestions for study, observation, and experiment, and to give page references to the book. Each lesson is accompanied by an examination paper covering the subject of the lesson. Students are required to satisfactorily answer these examination questions or discuss the topics there mentioned before they can receive a second lesson.—(Y. B. 1897.)

Instruction Trains.—Not the least important of the special methods employed to reach the farmer is the agricultural train. This form of institute activity has developed with great rapidity and promises to be an effective means of disseminating agricultural information. During the year 1911, 29 railroad instruction trains were run by 19 States with an attendance of 189,645.—(A. R. Ex. S. 1910 and 1911.)

Problem of Agricultural Education.—The solution of the problem of agricultural education has been summarized in the following way. Though written with particular regard to Canadian conditions, these remarks are applicable to a very great degree to conditions in America:

The ideal organization of the Department will be to have a specialist, an agent, a trained agriculturist, located in every county or district of the Province, paid by the Department and whose entire services will be at the disposal of the Department for the benefit of that county or district. This local representative would be the moving or directing spirit of every agricultural organization, assisting the farmers, directing special movements for improvement, inspecting, instructing, advising, reporting the appearance of any new pest or disease, procuring information in regard to all questions that farmers would ask, keeping the Department informed as to all agricultural conditions, and be the direct link between the farmers, the Agricultural College and the Department. In a dairy section this man should be a specialist in dairying, in a fruit growing district he should be a specialist in horticulture, and so on for all sections.

He should have an office where he could be found for consultation at stated times, and at other times he should be out among the farmers. He would be the directing man in the Agricultural Society, the Farmers' Institute, the Horticultural Society, the Farmers' Club. While he could not be expected to know all things, yet he would be able to procure information for them as might be desired. He would be the man "on the spot" to report new disease, new pests as soon as they arrive and to report to headquarters with a view to procuring help. Through him the special needs of the district could be investigated and all Departmental movements could be directed. He would be able to systematize a great deal of work that is now done spasmodically. He should be expected to go to the Agricultural College, say ten days or two weeks every year, to inform himself as to the new work there being done with the object of taking the results back to those farmers who are unable to visit the College. The result of personal contact would be found much more effective than through the sending of printed reports and bulletins. To put it in another form, he would increase many fold the value of printed publications.—(Teaching the Farmer How to Farm, by D. C. French.)

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* The reference, 2:326 means Vol. 2, page 326.

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